Technician Training for the Maintenance of In Situ Mosaics

2011 EDITION

The Getty Conservation Institute

Institut National du Patrimoine

MOSAIKON

Technician Training for the Maintenance of In Situ Mosaics

2011 Edition

Getty Conservation Institute
1200 Getty Center Drive, Suite 700
Los Angeles, CA 90049-1684, USA
Telephone: 310 440 7525
Fax: 310 440 7702
E-mail: gciweb@getty.edu
www.getty.edu/conservation

Institut National du Patrimoine
4, Place du Chateau
1008 Tunis
Tunisia
Telephone : 216 71 561 622
Fax : 216 71 562 452
E-mail : dginp@inp.rnrt.tn
www.inp.rnrt.tn

Design: Hespenheide Design

The Getty Conservation Institute works internationally to advance conservation practice in the visual arts—broadly interpreted to include objects, collections, architecture and sites. The Institute serves the conservation community through scientific research, education and training, model field projects, and the dissemination of the results of both its own work and the work of others in the field. In all its endeavors, the GCI focuses on the creation and delivery of knowledge that will benefit the professionals and organizations responsible for the conservation of the world's cultural heritage.

The Institut National du Patrimoine of Tunisia is a governmental and administrative institution with civil and financial autonomy. It works under the aegis of the Ministry of Culture and Protection of Heritage. The Institute's mission is both scientific and technical, and focuses on the inventory, study, protection, and presentation of the cultural, archaeological, historical, human, and artistic heritage of Tunisia.

MOSAIKON is a partnership of four institutions: the Getty Conservation Institute, the Getty Foundation, ICCROM, and ICCM. The aims of the project are to strengthen the network of professionals concerned with the conservation, restoration, maintenance, and management of mosaic heritage in the southern and eastern Mediterranean region; provide training to a variety of individuals involved in mosaics conservation and, more generally, with the management of archaeological sites and museums with mosaics; work with national and international bodies to provide a more favorable legislative, regulatory, and economic environment for the conservation of mosaics in the Mediterranean; and promote the dissemination and exchange of information.

ISBN: 978-0-9834922-5-2 (online resource)

Front cover photographs by Elsa Bourguignon, 2003 and 2004, and Richard Ross, 2002.

TABLE OF CONTENTS

PART 2
DETERIORATION AND INTERVENTIONS

ACKNOWLEDGMENTS

The current team engaged in training technicians for the maintenance of in situ mosaics for North African countries, within the framework of the MOSAIKON Project, would like to recognize the fundamental role that Jeanne Marie Teutonico, Associate Director of the Getty Conservation Institute, and Aïcha Ben Abed, Regional Coordinator of the MOSAIKON Project, have had in creating MOSAIKON and this training course. Lotfi Belhouchet, director of the site and museum of El Jem, Tunisia, has worked tirelessly to help make the course to be held at this site possible.

Several former staff members of the Getty Conservation Institute have contributed to developing the training methodology and teaching materials since 2001. We are grateful for the help provided by Dr. Elsa Bourguignon, between 2002 and 2007 as well as today, as co-author and editor of this latest version of the technician training course for the maintenance of in situ mosaics. We would also like to thank Amel Chabbi, Bettina Lucherini, Francesca Piqué and the interns Christian De Brer and Sebastiaan Godts for their past contributions.

We express our gratitude to Dana Reemes for his illustrations and his sense of humor that help enliven the text. We would like also to thank Debi van Zyl for the additional illustrations present in this latest version.

And, last but not least, to the trainees of the four previous courses in Tunisia who have collaborated in this teaching laboratory—we thank them for their patience and response to this work in progress.

Thomas Roby, teacher, conservator, Getty Conservation Institute

Livia Alberti, consultant teacher, conservator

Ermanno Carbonara, consultant teacher, conservator

FOREWORD

Over the course of the last century, archaeological excavations have revealed thousands of mosaic pavements from Classical Antiquity, from the Punic/Hellenistic periods to the Roman and Byzantine periods. Mosaics were an integral part of a wide variety of ancient buildings, from public bathhouses and churches to private houses and villas. Their decorative surfaces of stone and glass tesserae are important artistic evidence that sheds light onto the history, religions, and aesthetics of the ancient world. While excavations have raised public awareness of mosaics, they have also removed the soil and rubble that generally protected them for centuries. Once re-exposed and devoid of the protection provided by ancient walls and roofs, mosaic pavements are subjected to a range of destructive environmental forces and detrimental conditions, such as rain, sun, frost, ground water, pollution and growth of vegetation, as well as human neglect and misuse. Years of exposure to the environment results in the rapid deterioration and eventual loss of the tesserae surfaces, followed by that of the lime mortar foundation layers of the mosaic.

In the past, archaeologists responded to the conservation challenge of excavated mosaics by detaching and lifting the tesserae layer and relaying it on a new support, generally panels of reinforced concrete. The mosaics were then either exhibited or stored in a museum, or sometimes re-laid in situ or simply left somewhere on site. This was the fate of mosaics or parts of mosaics considered of greater importance or significance, due to their figurative subject or their intricate geometric design. The numerous mosaics of lesser importance and quality were often left in situ without any protection except for occasional cement mortar repairs to fill areas of surface loss. In recent decades, archaeologists and conservators have increasingly addressed the deterioration and loss of in situ mosaics. At the same time, both professions have recognized the importance of conserving all these figurative and geometric pavements whole and in their original architectural setting in order to better preserve the integrity of their cultural values and authenticity for the future. Preservation of mosaics in situ, however, requires a new approach to archaeological sites—one that recognizes sites not only as resources for current archaeological research and potentially for museum collections, but also as finite cultural resources whose values derive from their place within a landscape and that can benefit the public visiting the site and the surrounding community.

In addition to a different approach, better preservation of mosaics in situ and sites in general also requires people trained and employed specifically to manage and maintain a site on a daily basis. In many countries, there are not as yet enough people with these skills able to work on sites,

whether they are specialized workers or technicians, professionally trained conservators, or trained site managers. The training of technicians for the maintenance of in situ mosaics was undertaken as a first step towards the training of qualified personnel at all levels to maintain archaeological sites. In the future, their work on mosaics will need to be supervised directly by professionally trained conservators when they become available. The technicians will be part of a larger team that includes workers carrying out less specialized maintenance activities on a site as a whole, such as controlling vegetation and visitors. The work of the mosaic maintenance technicians will form an integral part of the prescribed activities of a site management and conservation plan to be developed and executed by the trained manager of the site. Such a plan would identify, among other things, which mosaics should be protected by reburial and then maintained; which should be protected by permanent shelters, presented to the public and maintained; which should be covered seasonally and maintained; and which should be left unprotected and maintained most frequently.

Despite the urgent need to address the deterioration and loss of in situ mosaics, many detached mosaics that were re-laid at archaeological sites over the past decades are in need of maintenance or a new support panel. Training in the conservation of in situ mosaics on their original bedding was considered a priority by the organizers because, before treating mosaics re-laid on reinforced concrete panels, it is important to be familiar with authentic ancient mosaics and know how to maintain them. The treatment of detached mosaics involves the use of different materials, tools and techniques because their modern supports, usually made of reinforced concrete, perform and deteriorate differently from ancient lime mortars. Therefore, it was considered more appropriate to envisage the treatment of detached and re-laid mosaics as a topic to be addressed at the end of the basic technician training on the maintenance of in situ mosaics.

The didactic materials presented hereafter were first developed for the training course on the maintenance of in situ mosaics organized in 2001 for workers employed by the Institut National du Patrimoine of Tunisia. They were designed to help them both during training campaigns on site and afterwards, during their future work as maintenance technicians. These didactic materials include summaries of the main topics taught during the course with references to supporting documents which are provided during the course as well. These materials also provide the trainees with a methodology for creating the documentation and carrying out the technical tasks involved in mosaic maintenance. This collection of documents, however, was not designed as a self-contained manual. It does not describe in detail, as a manual would, the different operations that are part of mosaic maintenance work, although these were, of course, part of the curriculum taught on site over several months, combining classroom lessons and practical exercises – all essential to a

basic training in this field. These teaching materials were designed for the trainees' average level of education, which generally was below or just at high school level, and were revised during the four training courses carried out in Tunisia between 2001 and 2008. This latest version has been created within the framework of the MOSAIKON Project for the first technician course for North African countries. Due to the rapid transition to digital photography and the rising number of computer-savvy trainees, this latest version provides a detailed presentation of the use of digital photography for documentation. It also refers to new supporting documents which will be provided during the course to assist the training using this technology. The maintenance of detached mosaics re-laid on reinforced concrete panels has also been taken into consideration in this 2011 edition.

This collection of training material was produced to be used by mosaic maintenance technicians during and after a short course combining several training sessions on site and independent practical exercises between sessions. The training is part of the broader MOSAIKON Project, a regional initiative which aims to strengthen the capacities of national authorities responsible for archaeological sites to better care for the large number of in situ mosaics located in their country. Training personnel already employed on sites with mosaics seemed to be an effective and immediate response to the lack of trained professional conservators or technicians specialized in mosaic conservation. However, to insure long-term effectiveness, the new profiles of "conservation technician" and "conservator" must be recognized as professions in their own right associated with specific grades within the State administration.

The training provided during this short course will enable technicians to considerably improve the condition of in situ mosaics and work independently on tasks corresponding to the technical level they have achieved. They will, however, need the supervision of a conservator to help them organize their work and guide them in operations above a certain level of difficulty and complexity. Their work is first of all based on the documentation and assessment of the condition of a mosaic, followed by interventions using lime mortars to stabilize in situ mosaics. Lifting mosaics is not part of their training, but the stabilization of already detached mosaics re-laid on modern supports is. Technicians are taught respect for the work of art and its authenticity, and consequently their stabilization work should not be excessive or visually obvious. Finally, the operation of mosaic reburial is taught because it is the only type of preventive conservation operation that technicians can implement without the help of a specialist. Reburial is necessary because there will never be sufficient human and financial resources to conserve on site, either exposed or under a shelter, all the mosaics that have been uncovered over more than a century.

It is important to realize that mosaic maintenance work is by nature a slow process that must be thorough in order to be effective. Technicians should frequently inspect the condition of the mosaic and their previous work, and treat it again if necessary, so as to prevent new damage as much as possible. This painstaking process of mosaic maintenance and their reburial are required to insure the conservation of in situ mosaics for the future.

INTRODUCTION TO THE MAINTENANCE OF IN SITU MOSAICS

A mosaic is a decorative surface finishing technique (see *Glossary*). It is made by inserting elements made of hard materials into a soft layer that holds them in place as it sets.

Mosaics found on archaeological sites are usually made of stone (commonly marble, limestone or sandstone), ceramic or glass elements inserted in a lime-based mortar. They often embellish the floors of a building, but they can also be used on vertical surfaces and vaults.

Opus tessellatum is the most common type of ancient pavement. It is characterized by the use of small sized elements (usually 5 to 20 mm wide), called **tesserae**. They have a more or less regular shape, usually quadrangular, and are cut by hand.

The outermost layer of a mosaic containing the tesserae is called **tessellatum**.

A mosaic is made by placing tesserae side by side in more or less regular rows, following an outline or filling a given space.

The tesserae of a mosaic can all be made of the same material and be of only one color, or be made of different materials and several colors. A mosaic made of tesserae of only one color is called **monochrome**; one made of two colors of tesserae, generally black and white, is called **bi-chrome**; a mosaic made of tesserae of several colors is called **polychrome**. A tessellatum containing two or more colors that create a geometric design is called a **geometric mosaic**. If the tessellatum forms a figurative image, it is called a **figurative mosaic**. Finally, some mosaics have both geometric and figurative designs. If the tesserae are extremely small—less than 4mm wide—the mosaic can be called ***opus vermiculatum***.

The layer into which the tesserae are inserted is called the **bedding layer**. It is made of a mortar very rich in lime so that it stays soft and workable over a long period. In addition, the bedding layer mortar is laid out a section at a time so that it remains soft during the whole tesserae inserting process.

A more or less simplified outline of the motifs to be created could be incised or painted on the surface of the last preparatory layer or of the bedding layer to guide the mosaicist when inserting the tesserae.

The stratigraphy of the preparatory layers supporting the tessellatum of a mosaic can vary depending on the construction period and the local traditions. The following description corresponds to the most common Roman tradition. The bedding layer is generally placed on one or two preparatory layers, which are usually made of lime-based mortars. The layer immediately below the bedding layer is called the **nucleus**, the layer below that is called the **rudus**. The rudus is normally thicker and made of a coarser mortar than the nucleus.

The foundation of the mosaic is made of an initial layer called the **statumen**, used to create a leveled surface and to stabilize the ground to avoid settlement and deformation. The thickness of the statumen can vary and it is often made of large stones pushed into the ground or set with a coarse mortar.

In some mosaic pavements, or sometimes in mosaics on vertical surfaces, a small mosaic panel (usually less than a square meter) made in *opus vermiculatum* is inserted. This panel, called the **emblema**, is generally made separately on a stone slab or large ceramic tile in a workshop prior to the making of the mosaic into which it is inserted. This type of mosaic was also made as a portable work of art, independent from any building.

Apart from *opus tessellatum*, there are other types of ancient mosaics with similar preparatory layers. Some of the most common are:

Opus scutulatum is composed of a usually monochrome *opus tessellatum* background into which fragments of stone slabs of different colors and of generally irregular shapes are inserted.

Opus sectile is made of stone slabs, most often different colored marble, cut with a saw into regular shapes and often placed side by side to create a geometric or figurative design.

Opus figlinum is usually made of ceramic fragments of the same size and of rectangular shape, inserted along their broken edges. The fragments are assembled in groups of a few tesserae (2 to 4) which are placed side by side to create the impression of a basket weave pattern.

When the tesserae are of different colors and of materials other than ceramic, the pavement is called ***opus pseudo-figlinum***. When the ceramic elements are arranged in a herringbone pattern, it is called ***opus spicatum***.

Opus signinum is made of a lime mortar mixed with ceramic fragments into which quadrangular tesserae or small stone fragments are inserted at random, in lines or following simple geometric designs.

When this type of pavement does not include inserted elements, it is called ***cocciopesto***.

MAINTENANCE

Mosaics exposed on site can only be preserved through regular maintenance to reduce the impact of destructive environmental forces and being walked on. Maintenance consists of a series of operations that includes a preliminary study of the mosaic, initial stabilization work, and periodic inspection of the mosaic's condition followed by, if needed, planned interventions to protect and stabilize it.

Periodic inspection begins with collecting data about the mosaic, its condition and the condition of previous interventions. This information is needed to assess how urgently interventions are needed, to estimate the type and amount of work to be done, and to organize the work. Once this planning is done, remedial stabilization measures can be implemented and protective interventions can begin. Each time the condition of a mosaic is inspected, a new maintenance cycle begins. It is essential to refer to the documentation of the last inspection to study the evolution of the deterioration processes and the performance of the previous interventions.

The entire maintenance process, but in particular collecting data about the mosaic, planning work, and archiving the created documentation, requires a close collaboration between the specialized maintenance staff and the site manager who plays a central role in the management of the archeological heritage.

PART I

Documentation

CHAPTER 1

DOCUMENTATION METHODOLOGY FOR MOSAIC MAINTENANCE

Documentation is the collection of all information concerning the mosaic. It is an essential component of any maintenance work. It provides a better understanding of a mosaic and its condition before work is begun, and makes it possible to record all the work carried out on the mosaic. Documentation carried out during the regular inspection of a mosaic is a means to follow the evolution of its condition through time and to evaluate the efficiency of maintenance work.

Documentation can be generated in different formats:

- written, by filling out *data forms*;
- graphic, by drawing *maps* accompanied by their *legends*;
- photographic, by taking *photographs* recorded on the *photograph log*.

These three documentation formats can be created by hand or using a computer.

All documentation collected during a maintenance campaign can be divided into three successive phases:

1. Study phase
2. Planning phase
3. Intervention phase

STUDY PHASE

In this first phase, information on the construction of the mosaic during Antiquity, the work done on it in the past and its current condition is collected. This data is recorded in written format on three data forms. Each of the three data forms is accompanied by illustrative documents, including maps with their legends, photographs, etc.

- *Data Form No. 1 – Identification* (page 11) supplemented by a building plan indicating the location of the room where the mosaic is situated and an overall photograph of it.
- *Data Form No. 2 – Previous Interventions* (page 15) with the Previous Interventions Map and its legend (page 16)
- *Data Form No. 3 – Condition Assessment* (page 19) with the four Condition Assessment Maps and their legends (pages 20–23)

PLANNING PHASE

Work to be done will be planned on the basis of the data collected during the study phase. This planning phase is recorded in writing only by completing:

- *Data Form No. 4 – Intervention Planning* (page 25)

INTERVENTION PHASE

The programmed work is carried out during the intervention phase. All interventions on the mosaic are documented in written and graphic formats by completing:

- *Data Form No. 5 – Current Interventions* accompanied by the *Current Interventions Map* and its legend (page 28)

WRITTEN AND GRAPHIC DOCUMENTATION

Written documentation helps to collect information about the mosaic.

To create the written documentation, a series of data forms is used, organized by step and subject, which must be filled in order to gather information in a complete and orderly manner.

Graphic documentation helps to precisely record the position of information on the mosaic surface.

To produce graphic documentation, a *base* is used from which various *maps* are made. A *base* is a drawing (***base drawing***) or a photograph (***base photograph***) of the mosaic. A *map* is a record of different data pertaining to the mosaic, which are represented by various symbols and colors. A *map* must always be associated with its *legend* which is an explanatory list of the colors and symbols used on the *map*.

Data Forms and **Maps** are actual tools to collect data about the mosaic enabling the planning and the evaluation of maintenance interventions.

DATA FORMS AND MAPS

Data Form No. 1 – Identification

Information on the mosaic is gathered in Data Form No. 1, such as its location within the archaeological site, building and room, its dimensions, and its original construction technique. Data Form No. 1 also helps to collect, and provides references to, pre-existing documentation on the mosaic (i.e. past articles; excavation reports; old photographs; plans; drawings; references to the country's national mosaic corpus, if it exists for the site; other publications, etc.).

A unique "name" or identifier can be assigned to each mosaic using the information collected in Data Form No. 1. From then on, this identification name of the mosaic, or *Mosaic ID*, should be used in all written, graphic and photographic documentation pertaining to the mosaic. The *Mosaic ID* comprises letters and numbers corresponding to the abbreviations of the site, building and room where the mosaic is located. If there already are letters and numbers assigned to the building and room (for example, from the national mosaic corpus or from an excavation report), these should be used. If none exist, new ones should be created under the guidance of the site manager.

DATA FORM NO. 1 – IDENTIFICATION

STUDY PHASE

MOSAIC ID _______ /_______ /_______ /_______

This form must be completed with the site manager. It should be supplemented by an overall photograph of the mosaic and a plan of the building indicating the location of the room.

SITE

BUILDING

ROOM

SECTIONS, FRAGMENTS OR LEVELS
(Use Arabic numerals for sections, letters for fragments, Roman numerals for levels)

MOSAIC ID _______ /_______ /_______ /_______
(Abbreviation of the site / building / room / sections or fragments or levels)

EXISTING DOCUMENTATION ABOUT THE MOSAIC AND ITS CONSERVATION
(References of publications, plans, photographs, drawings and other documents)

DATE OF MOSAIC EXCAVATION:

DIMENSIONS AND NUMBERING OF FRAGMENTS, SECTIONS OR LEVELS

(Use an existing drawing or make a sketch of the mosaic indicating the north and the walls of the room)

GENERAL OBSERVATIONS ON THE CONSTRUCTION TECHNIQUE

(Type of pavement, decoration, materials, colors, tesserae size, etc.)

PREPARED BY **DATE**

If need be, one can add to the abbreviations of the site/building/room:

- an Arabic numeral (1, 2, 3, 4…) for each section, when it is necessary to divide a mosaic to document it graphically;
- a letter (A, B, C, D…) for each fragment of a mosaic that is in several pieces;
- a Roman numeral (I, II, III, IV…) for each level if there are several mosaics one on top of another; level I being the more ancient.

Figure 1 illustrates the different ways of labeling the different sections, fragments or levels of a mosaic.

An example of how a *Mosaic ID* is composed: for a mosaic on the site of Utica (UT), in the building of the Maison de la Cascade (MC), in room 23 (23), and for the third section of the mosaic (3), the *Mosaic ID* will be UT/MC/23/3.

Data Form No. 1 also contains a space in which to sketch the walls of the room and the outline of the existing mosaic. In addition, this sketch should include the dimensions of the mosaic, or of its different fragments. The numbers of the sections and/or letters of the fragments should also be recorded in the sketch.

Data Form No. 1 should also come with an overall photograph of the mosaic and a plan of the building showing the location of the room in which the mosaic is situated.

This form is only filled out once for each mosaic, the first time it is documented. It must be completed with the person responsible for the site.

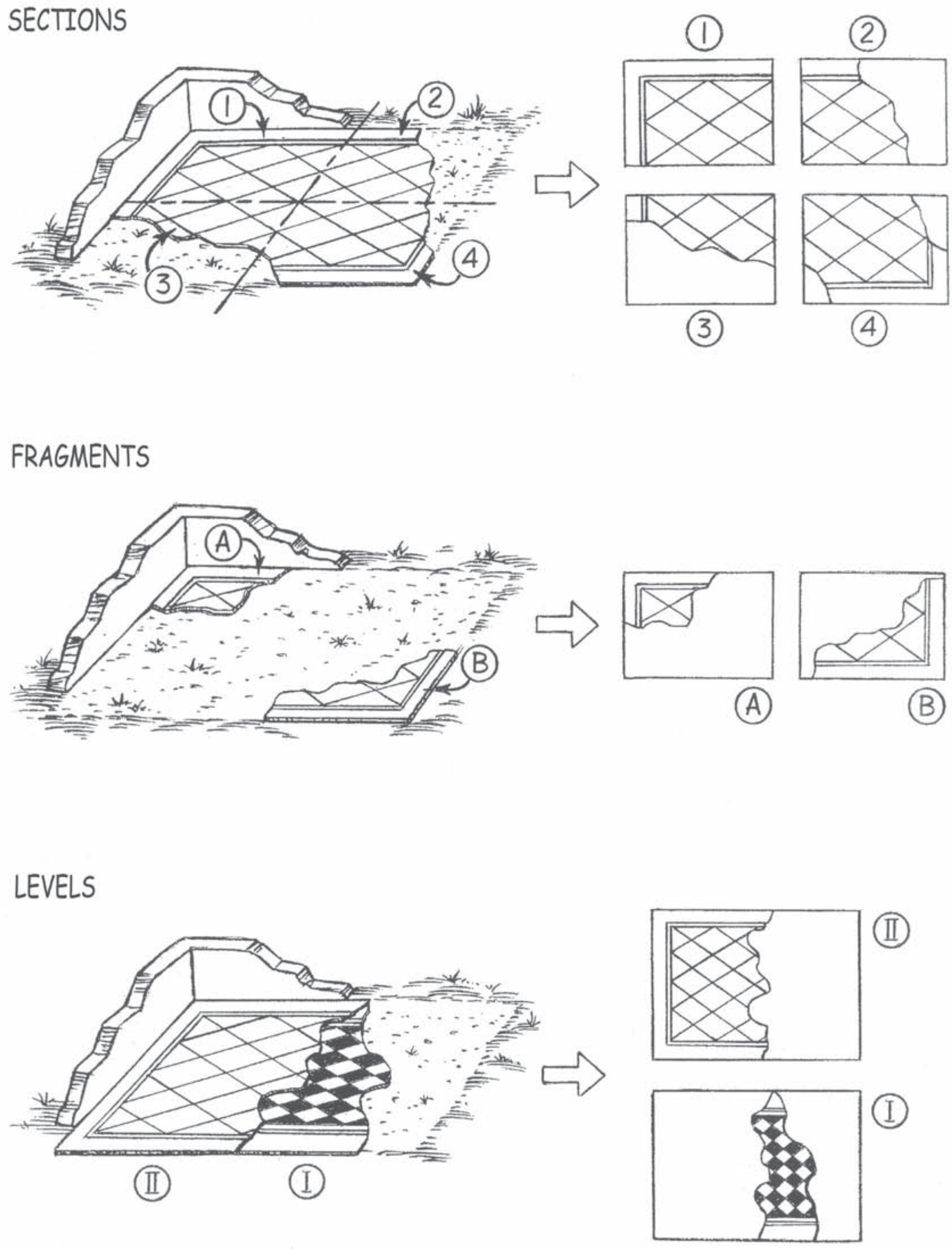

FIGURE 1 **Labeling the different sections, fragments or levels of a mosaic**

Data Form No. 2 – Previous Interventions

Data Form No. 2 contains information related to maintenance, restoration and protection operations carried out on and around the mosaic in the past. These previous interventions can date from Antiquity or can be modern.

Data Form No. 2 is accompanied by separate graphic documentation in the form of a map with its legend.

Previous Interventions Map

Areas where different interventions were completed in the past on or around the mosaic are indicated on this map using different colors or symbols. If there is not enough room on the legend sheet to describe all the existing previous interventions, an *Additional Sheet* should be used for the legend (page 17).

Data Form No. 2 – *Previous Interventions* is completed and the *Previous Interventions Map* is created during the initial intervention. It may be necessary to redo them at the beginning of the maintenance cycle if old mortars have been replaced during this first intervention.

DATA FORM NO. 2 – PREVIOUS INTERVENTIONS

STUDY PHASE

MOSAIC ID _______ /_______ /_______ /_______

PREVIOUS INTERVENTIONS ON THE MOSAIC

Mortar repairs
- ❑ Infilling of lacunae
- ❑ Edging repair
- ❑ Filling of interstices between tesserae
- ❑ Grouting of voids between preparatory layers

Reintegration of lacunae
- ❑ with tesserae
- ❑ with pieces of stone, brick or other material inserted into the mortar

Lifting and relaying on a new support
- ❑ Reinforced concrete/cement support
- ❑ Other type of support: __________

Surface treatment
- ❑ Chemical cleaning
- ❑ Mechanical sanding
- ❑ Application of a surface product (resin, wax, etc.)
- ❑ Other: __________

❑ Parts detached and stored elsewhere

❑ Reburial *(Draw a vertical section of the reburial: describe the fill materials and separation membranes used, provide the total thickness and the thickness of each layer)*

PREVIOUS INTERVENTIONS AROUND THE MOSAIC

❑ Drainage	❑ Open shelter	❑ Wall stabilization
❑ Removable cover	❑ Closed shelter	❑ Other: __________
❑ Access barrier: __________		

DATES OF PREVIOUS INTERVENTIONS CARRIED OUT AND INFORMATION SOURCES

PREPARED BY **DATE**

LEGEND – PREVIOUS INTERVENTIONS MAP

MOSAIC ID ______ /______ /______ /______

Mortar repairs

☐ Infilling of lacunae

☐ Edging repair

☐ Outline of each infilling or edging mortar

☐ Overlapping between mortar layers (new → old)

☐ Filling of interstices between tesserae

☐

Reintegration of lacunae

☐ Reintegration with tesserae

☐ Reintegration with:

Detached mosaics

☐ Outline of the support panels of a detached mosaic relayed in situ

☐ Location of the metal reinforcements of the support panels

☐ Parts detached and stored elsewhere

☐ Reburial outline

☐ Drainage openings

☐

Other types of interventions

☐

PREPARED BY **DATE**

ADDITIONAL SHEET
LEGEND – MAP ....

MOSAIC ID ________ /________ /________ /________

PREPARED BY **DATE**

Data Form No. 3 – Condition Assessment

Data Form No. 3 is used to record the different types of deterioration presently observed on the mosaic, as well as the condition of past interventions carried out on or around the mosaic. Current exposure conditions of the mosaic are also recorded. This information serves to assess the general condition of the mosaic and the degree of urgency of any intervention.

Data Form No. 3 is accompanied by separate graphic documentation in the form of four location maps and their legends.

Condition Assessment Maps – No. 1, No. 2, No. 3 and No. 4

The location of different types of deterioration is mapped on each of these maps. The four *Condition Assessment Maps* are:

- *Map No. 1 – Structural Deterioration*
- *Map No. 2 – Surface Deterioration*
- *Map No. 3 – Presence of Bio-Deterioration Agents*
- *Map No. 4 – Deterioration of Interventions*

Maps No. 1, No. 2 and No. 3 are used to record the condition of the mosaic itself, whereas map No. 4 is used to record the deterioration of past interventions (legends pages 20–23).

The condition of a mosaic should be regularly monitored through time. At each new inspection, a new *Data Form No. 3 – Condition Assessment* should be filled out recording only the new deterioration phenomena that have occurred since the last inspection or the last intervention.

DATA FORM NO. 3 – CONDITION ASSESSMENT

STUDY PHASE

MOSAIC ID _______ /_______ /_______ /_______

INSPECTION TYPE ❑ Initial inspection ❑ Maintenance cycle

PRESENT EXPOSURE CONDITIONS

❑ In open air ❑ Reburied ❑ Under an open shelter
❑ Walked on ❑ Under a removable cover ❑ Under a closed shelter
❑ Parts not excavated or inaccessible

During the initial inspection, check the boxes of all the deterioration phenomena that are present. During maintenance cycles, only indicate new deterioration phenomena that have occurred since the last inspection or last intervention.

STRUCTURAL DETERIORATION *(Condition Assessment Map No. 1)*

❑ Tessellatum lacunae
❑ Cracks
❑ Bulges
❑ Depressions
❑ Detachments between mosaic layers

SURFACE DETERIORATION *(Condition Assessment Map No. 2)*

❑ Detached tesserae
❑ Deteriorated tesserae
❑ Deteriorated mortar between tesserae
❑ Stains
❑ Incrustations
❑ Efflorescence

PRESENCE OF BIO-DETERIORATION AGENTS *(Condition Assessment Map No. 3)*

❑ Micro-organisms
❑ Vegetation
❑ Tunnels or entrance holes made by insects and other animals

DETERIORATION OF INTERVENTIONS *(Condition Assessment Map No. 4)*

❑ Deteriorated lacunae fills or edging repairs
❑ Deteriorated mortar between tesserae
❑ Re-detached tesserae
❑ Deteriorated support panels
❑ Deteriorated support metal reinforcements

Reburial:
❑ Presence of vegetation
❑ Loss of fill materials
❑ Deteriorated separation membranes

DETERIORATION OF INTERVENTIONS AROUND THE MOSAIC

❑ Clogged drainage
❑ Stabilized walls with new deterioration
❑ Deteriorated cover or shelter
❑ Damaged access barrier
❑ Other: _______________

OBSERVATIONS ON THE CONDITION ASSESSMENT

GENERAL CONDITION OF THE MOSAIC

❑ **Good** ❑ **Fair** ❑ **Bad**

❑ Date recommended for next inspection: _______________
(No intervention required)

❑ Date recommended for intervention: _______________
(Intervention required - fill out Data Form No. 4)

PREPARED BY **DATE**

2011

LEGEND – CONDITION ASSESSMENT MAP NO. 1

STRUCTURAL DETERIORATION

MOSAIC ID ________ /________ /________ /________

☐ Tessellatum lacunae

☐ Cracks

☐ Bulges

☐ Depressions

☐ Detachments between mosaic layers

☐

☐

☐

☐

☐

PREPARED BY **DATE**

LEGEND – CONDITION ASSESSMENT MAP NO. 2

SURFACE DETERIORATION

MOSAIC ID ________ /________ /________ /________

☐	Detached tesserae
☐	Deteriorated tesserae
☐	Deteriorated mortar between tesserae
☐	Stains
☐	Incrustations
☐	Efflorescence
☐	
☐	
☐	
☐	

PREPARED BY **DATE**

LEGEND – CONDITION ASSESSMENT MAP NO. 3

PRESENCE OF BIO-DETERIORATION AGENTS

MOSAIC ID ________ /________ /________ /________

☐ Micro-organisms

☐ Vegetation

☐ Tunnels or entrance holes made by insects and other animals

☐

☐

☐

☐

☐

PREPARED BY **DATE**

LEGEND – CONDITION ASSESSMENT MAP NO. 4
DETERIORATION OF INTERVENTIONS

MOSAIC ID _______ /_______ /_______ /_______

☐	Deteriorated lacunae fills or edging repairs
☐	Deteriorated mortar between tesserae
☐	Re-detached tesserae or detached tesserae of a re-laid mosaic
☐	Deformed mosaic support panels
☐	Bulging areas in support panels
☐	Visible deterioration of metal reinforcements in support panels
☐	Detachment between tessellatum and support panels
☐	Cracks in mosaic support panels
☐	
☐	

PREPARED BY **DATE**

Data Form No. 4 – Intervention Planning

Data Form No. 4 is used to estimate the time and personnel needed to carry out each intervention. For each operation, a first estimate of the number of work days required for one technician will be calculated. The number of work days necessary for a group of technicians to completely stabilize a mosaic is then assessed, factoring in the time to organize labor and any other circumstance that might affect the process.

During this phase, the need for a conservator to intervene on the mosaic to solve the most difficult conservation problems will be determined. Other types of work on site that may be needed should also be noted, such as the construction of a shelter or the creation of a visitors' path, which requires the intervention of a specialist, such as an architect or an engineer.

This data form must be filled out under the guidance of the site manager.

DATA FORM NO. 4—INTERVENTION PLANNING

PLANNING PHASE

MOSAIC ID ______ /______ /______ /______

This form must be completed with the site manager.

TIME REQUIRED FOR ORGANIZATION AND COMPLETION OF THE WORK

❑ Vegetation removal ____ work days for 1 technician
Notes:

❑ Cleaning ____ work days for 1 technician
Notes :

❑ Removal of modern repair mortars ____ work days for 1 technician
Notes:

❑ Resetting tesserae ____ work days for 1 technician
Notes:

❑ Filling interstices between tesserae ____ work days for 1 technician
Notes:

❑ Grouting voids between preparatory layers ____ work days for 1 technician
Notes:

❑ Infilling lacunae and edging repairs ____ work days for 1 technician
Notes:

❑ Removal and resetting tesserae with facing ____ work days for 1 technician
Notes :

❑ Removal or treatment of support metal reinforcements ____ work days for 1 technician
Notes:

❑ Drainage ____ work days for 1 technician
Notes:

❑ Reburial ____ work days for 1 technician
Notes:

❑ Documentation ____ work days for 1 technician
Notes:

❑ Material preparation ____ work days for 1 technician
Notes:

❑ Other ____ work days for 1 technician
Notes:

TOTAL WORK DAYS FOR 1 TECHNICIAN: ________

Number of days / weeks / months: ______________ for Number of technicians: __________

❑ INTERVENTION BY A SPECIALIST NEEDED ON OR AROUND THE MOSAIC
Notes:

PREPARED BY **DATE**

Data Form No. 5 – Current Interventions

This data form records the operations carried out on and around the mosaic. The dates of the last intervention and last inspection (if known), as well as the date and duration of the current work and the date recommended for the next inspection, are also recorded on this form.

Current Interventions Map

The locations of the different types of executed interventions are marked on this map. The composition of different mortars used for each intervention should be recorded on the legend of the *Current Interventions Map*. If there is not enough room on the legend sheet (page 28) to describe all the interventions, an *Additional Sheet* should be used for the legend (page 29).

During each new intervention campaign, a new *Data Form No. 5 – Current Interventions* should be filled out and a new *Current Interventions Map* drawn.

DATA FORM NO. 5—CURRENT INTERVENTIONS

INTERVENTION PHASE

MOSAIC ID _______ /_______ /_______ /_______

INTERVENTION TYPE ❑ Initial intervention ❑ Maintenance cycle

DATE OF PREVIOUS INTERVENTION

DATE OF PREVIOUS INSPECTION

DATE AND LENGTH OF CURRENT WORK

DATE RECOMMENDED FOR THE NEXT INSPECTION

TREATMENTS CARRIED OUT ON THE MOSAIC

❑ Vegetation removal
❑ Cleaning of the entire surface
❑ Cleaning of part of the surface
❑ Removal of modern repair mortars
❑ Resetting tesserae
❑ Filling interstices between tesserae
❑ Grouting voids between preparatory layers
❑ Infilling lacunae and/or edging repairs
❑ Removal and resetting tesserae with facing
❑ Removal of metal reinforcements in support panels
❑ Treatment of metal reinforcements in support panels
❑ Drainage
❑ Reburial *(Draw a vertical section of the reburial: describe the fill materials and separation membranes used, provide the total thickness and the thickness of each layer)*

INTERVENTIONS CARRIED OUT AROUND THE MOSAIC

❑ Wall stabilization
Notes:

❑ Other: __________
Notes:

NAMES OF THE TECHNICIANS WHO CARRIED OUT THE WORK

PREPARED BY **DATE**

LEGEND—CURRENT INTERVENTIONS MAP

MOSAIC ID _______ /_______ /_______ /_______

- [ ] Vegetation removal
- [ ] Cleaning of part of the surface
- [ ] Resetting tesserae
  Mortar composition:
- [ ] Filling interstices between tesserae
  Mortar composition:
- [ ] Grouting voids between preparatory layers
  Mortar composition:
- [ ] Infilling of lacunae and/or edging repair
  Mortar composition:
- [ ] Infilling of lacunae and/or edging repair
  Mortar composition:
- [ ] Infilling of lacunae and/or edging repair
  Mortar composition:
- [ ] Facing with adhesive:
- [ ] Removal and resetting tesserae with facing
- [ ] Removal of metal reinforcements in support panels
- [ ] Treatment of metal reinforcements in support panels
- [ ] Drainage openings
- [ ] Reburial

PREPARED BY **DATE**

ADDITIONAL SHEET
LEGEND—MAP ....

MOSAIC ID ________ /________ /________ /________

PREPARED BY DATE

2011

Revision of the base drawing or base photograph

After the interventions have been carried out, the mosaic is clean and stabilized; its surface is therefore more visible. An inspection should be made to see if there are any differences between the base drawing or photograph that was already used to make the Maps, and the true outline and decorative motifs of the mosaic which are now entirely visible. If there are significant differences, the base drawing will be corrected or a new base photograph will be created.

This corrected base drawing or photograph should be dated and used to make the Maps during subsequent maintenance cycles.

PHOTOGRAPHIC DOCUMENTATION

During the study and intervention phases, photographic documentation is carried out to record the condition of the mosaic before and after the work and to illustrate certain details. Photography also helps to document a mosaic in a more direct and realistic way during the phases of maintenance work. It is well-suited to illustrating certain conditions, such as the seriousness of some types of damage; however, other types of information can only be represented graphically because they are not visible. For example, the extent to which micro-organisms are present can be documented using a photograph, while detachment between preparatory layers can only be represented using graphic documentation.

Photography is also used at the beginning of the study phase to take an overall image of the mosaic which will be attached to *Data Form No. 1 – Identification*. It is also often used to create a base image which will be used to make the maps.

At the end of an initial intervention of cleaning and stabilisation, a new overall photograph of the mosaic should be taken to record its current condition. The photograph should then be attached to Data Form No. 1.

Photographs are generally taken using a digital camera. Traditional cameras with photographic films are still occasionally used, but it is becoming more and more difficult to find film, and to have it developed.

At the time the photographs are taken, it is strongly recommended that the *Photograph Log* be filled in, in order to remember the subject and the reason for taking the photos once they are uploaded to the computer.

In the column “Digital file No.” of the *Photograph Log*, the digital photo number given by the camera should be copied (page 64). For each photo taken, the ID of the photographed mosaic, the date and category of the photo and a note about its subject should also be recorded in the *Photograph Log* (pages 37–39). When the photographs are transferred from the camera to the computer, the *Photograph Log* will be used to rename and archive them correctly (see *Transfer and Archiving of Digital Photographs*). The *Photograph Log* can then be disposed of.

To be able to identify the photographed mosaic and its orientation on the photographs, a small chalkboard on which is written the ID of the mosaic, the date the photo was taken and the direction North should be present within the frame of each photo.

Detail photographs can document specific aspects or be used as a tool or “working aid” during some stabilization phases. In this case, a *Photograph Map* should be made, to make it easier to find again the position of these details on the mosaic. On a base drawing or photograph, the frame of each photo should be represented by a rectangle, with the corresponding digital photo file number written in its upper interior corner. This same number will be kept in the photo name, in the 4th part “Note on the subject”, when the photo is given its final name for archiving purposes (page 38).

PHOTOGRAPH LOG

SITE NAME ______________________

LOG SHEET NUMBER ______________________

Digital file No.	Mosaic ID	Date	Category	Note on the subject

CATEGORIES:

1**ID**: Identification
2**PI**: Previous Interventions
3**CA**: Condition Assessment
4**PL**: Planning
5**CI**: Current Interventions
6**WA**: Working Aid

ARCHIVING

All the documentation components created during the mosaic maintenance process, whether in paper form or in digital form, should be properly organized and conserved so that they can be readily accessed and used in the future.

These documents together form the mosaic conservation archive of a site. The archiving of the documentation is therefore a very important step in the mosaic maintenance process.

Archiving of paper documentation

All data forms, base drawings or photographs, maps with their legends and printed photographs pertaining to a mosaic must be placed in the same folder or binder. All the documentation components for a given mosaic (data forms, maps and photographs) must be listed on the *Archiving Data Form*.

Archiving Data Form

This data form lists the documentation components contained in the folder pertaining to a mosaic. After creating each document during the initial intervention campaign, the date it was created should be recorded on the corresponding line in the first column of the form. New documents created during each subsequent maintenance cycle are then added to the folder and grouped together by intervention campaign. Their date of creation should be written in a new column of the *Archiving Data Form*. Thus, there is only one *Archiving Data Form* per mosaic.

In summary, the documents to be archived during the maintenance of a mosaic are the following:

- Base drawing or photograph
- Data Form No. 1 – Identification and building plan and overall photograph
- Data Form No. 2 – Previous Interventions and Map with its legend
- Data Form No. 3 – Condition Assessment and Maps No. 1, No. 2, No. 3 and No. 4 with their legends
- Data Form No. 4 – Intervention Planning
- Data Form No. 5 – Current Interventions and Map with its legend
- Traditional photographic prints and/or printed digital photographs with Photograph Map
- Revised base drawing or photograph

ARCHIVING DATA FORM

SITE NAME ____________________

MOSAIC ID ______ /______ /______ /______

	DATES OF COMPLETION *(month and year)*							
	Initial Campaign	Maintenance Cycles						
Base drawing/photograph								
Data Form No.1 – Identification								
Building plan and overall photograph								
Data Form No. 2 – Previous Interventions								
Map and Legend – Previous Interventions								
Data Form No. 3 – Condition Assessment								
Map and Legend – Condition Assessment Map No. 1								
Map and Legend – Condition Assessment Map No. 2								
Map and Legend – Condition Assessment Map No. 3								
Map and Legend – Condition Assessment Map No. 4								
Data Form No. 4 – Intervention Planning								
Data Form No. 5 – Current Interventions								
Map and Legend – Current Interventions								
Printed photographs								
Photograph Maps								
Revised base drawing/photograph								

All the documentation for a site should be arranged by building. Folders for mosaics within the same building should be filed together in the same archive box. Copies of existing documentation that may have been found (i.e. old photos from the excavation, published articles, etc.) and a site plan showing the location of the building in question should also be placed in a building's archive box.

The archive should be left on site in the care of the site manager and must be stored in a dry, cool area away from sunlight. A second copy of this documentation can be stored in the national archives.

Archiving of digital documentation

All digital files created during the documentation of a mosaic should be organized on the computer so that they can be easily located now and in the future. It will be necessary to create a filing system with digital folders (Figure 2). The main folder containing all the information about a

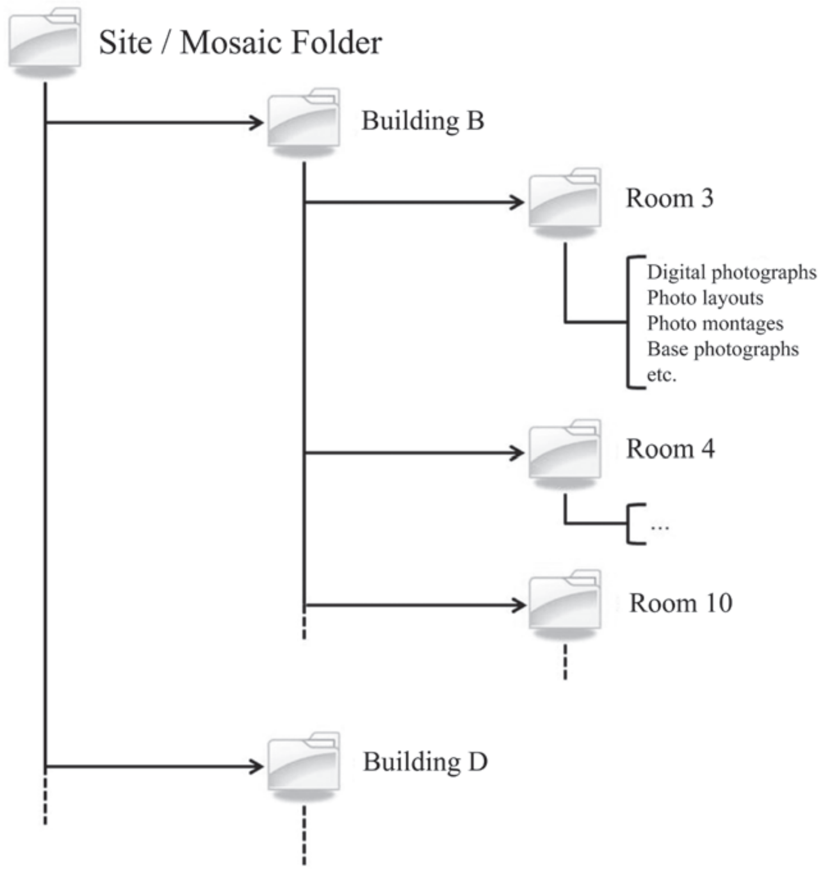

FIGURE 2 Digital Filing System

site should contain a separate folder for each building that has mosaics. Each building folder should have a sub-folder for each room that has mosaics. The room folder should contain all the digital files (photos, photo layouts, photomontages, etc.) pertaining to the mosaic of this room.

All files, once uploaded to the computer, such as digital photos (see *Transfer and Archiving of Digital Photographs*), should be renamed. Their new name is composed using the method explained hereafter. This file name format should also be used to name files created directly on the computer, such as photomontages of digital photos (see *Photomontage of Digital Photographs*) or photo layouts (see *Layout of Digital Photographs*).

A **file name** comprises 5 parts. Underscores ("_") should be used between each part. The following model should be followed so that all files may be automatically organized in alphabetical and chronological order by the computer.

Part 1: The **Mosaic ID** used in all written documentation comes first. For file names, dashes (symbol "-") rather than forward slashes (symbol "/") should be used between the different parts of the ID because computers do not accept forward slashes in file names. For example, DG/Th1/11 will become in the file name DG-Th1-11.

Part 2: Next comes the **date** when the photo was taken or when the document was created. The date should be written starting with the year, followed by the month and the day, using dashes between each part. For example: May 15, 2006 will be written in the file name as 2006-05-15.

Part 3: After that, the abbreviation for the **category** of the photo or document, that is, its general theme, should be added. The six possible categories and their abbreviations are as follows:

- 1ID for documents relating to *Data Form No. 1 – Identification*. This category should be used for general photographs of the mosaic context, for photographs used to create a base photograph, as well as any detail photographs illustrating the execution technique of the mosaic. More generally, it should be used for any documents concerning the mosaic construction technique, its history and its identification;
- 2PI for photographs and documents relating to Previous Interventions;
- 3CA for photographs and documents relating to the Condition Assessment;

- 4PL for documents relating to the Intervention Planning;
- 5CI for photographs and documents taken after and/or during Current Interventions;
- 6WA for photographs and documents that are used as Working Aids, that is, as visual references to assist in carrying out a treatment.

Part 4: The file name should be completed by a short descriptive **note** that should describe its subject more precisely. This note should be written with the help of the technical vocabulary found in the map legends and the illustrated glossary (see *Glossary*). If the description consists of several words, the note should not contain any spaces, but rather the first letter of each word will be capitalized: for example, if the description of a photograph is "Before the resetting of tesserae", the note will be shortened to "BeforeResettingTesserae".

The note should also serve to indicate whether a file is used as a base photograph. For example, DG-Th1-11_2006-05-15_1ID_BasePhoto will be the name for the base photograph of the mosaic DG/Th1/11.

If the number given by the digital camera to a digital photo has been written on the *Photograph Map*, this number will be kept as the fourth part of the file name without adding a supplementary short descriptive note. For example, the file name DG-Th1-11_2006-05-15_6AT_DSC34689 is the digital photo number DSC34689 written on the *Photograph Map* of the mosaic DG/Th1/11.

In any case, this fourth part of the file name should be kept as short as possible as some computer software does not accept file names longer than 32 characters.

Part 5: If several files of the same format (.doc, .jpg, etc.) have the same ID, date, and subject (category and note), part 5 of the file name should be used to **number** them (01, 02, 03, etc.) to insure that each file has a different name.

At the end of a file name, a suffix (also called a file extension) indicates the file format. It is always preceded by a dot. It is dictated by the program with which the file was created and it is normally added automatically by the software.

Thus, a file name should comply with the following model:

Mosaic ID	Date	Subject		Number
		Category	**Note**	
Site-Building-Room-Division	yyyy-mm-dd	• 1ID (IDentification) • 2PI (Previous Interventions) • 3CA (Condition Assessment) • 4PL (Planning) • 5CI (Current Interventions) • 6WA (Work Aid)	(Use the technical vocabulary found in the map legends and the illustrated glossary)	(If two files share the same ID, date, subject and format)
Example				
DG-Th1-11-2	2006-05-10	6WA	BeforeResettingTesserae	04

DG-Th1-11-2_2006-05-10_6WA_BeforeResettingTesserae_04

At the end of each intervention campaign on a mosaic, or if possible more often, the digital files contained in the work computer should be backed-up onto compact discs (CD or DVD). The data pertaining to each room or each building should be burned on a CD, or several if necessary, and include all the electronic files created during the campaign and all previous campaigns. On each CD itself, using a permanent marking pen, the content, the full IDs of the mosaics, and the dates of the maintenance campaigns during which the files were created should be written. Each CD should be stored in its individual box or in a CD envelope affording long-term protection, and should then be filed in the folder of the corresponding room or the archive box of the corresponding building.

It is important to create at least one back-up archival copy of the digital files in the event that the computer loses data (due to improper handling, presence of a virus, computer material deteriorated by water, etc.). Another copy can be kept in the national heritage archives.

When the computer memory is full, it works much slower. In this case, all the files should be saved on an external hard drive which will be kept on site to insure the long-term conservation of digital images and documents. Afterwards, the digital files should be deleted from the computer to free up space on the computer's hard drive.

Using a scanner connected to a computer, traditional photographic images (negatives, slides or prints) can also be transformed into digital images, which can then be printed. Scanning may also be used to create a digital copy of any other documents created on paper (Data Forms, Maps and Legends) to safeguard them in a digital format.

DOCUMENTATION AND ARCHIVING DURING THE MAINTENANCE CYCLES

Regular **maintenance cycles** should follow the initial stabilization intervention of a mosaic and they should include the periodic inspection of the condition of the mosaic and of past interventions, as well as the execution of newly needed interventions (Figure 3). It is important to inspect the mosaic regularly, at least once a year.

When filling out a new *Data Form No. 3 – Condition Assessment*, only the deterioration phenomena that have occurred since the last inspection or intervention should be recorded. If some of these phenomena seem to reoccur from one intervention campaign to the next, these observations should be noted in the space reserved for comments on the data form.

Inspecting the condition of the mosaic provides the opportunity for assessing the need and the urgency of a new intervention campaign. If the general condition is good, another inspection will be scheduled at a later date. If new deterioration phenomena have appeared, it will be necessary to schedule a new intervention. At this time, a new *Current Interventions Map* will be drawn, using the base drawing or photograph that was revised after the initial intervention (corrected drawing or new overall photo). A new *Data Form No. 5 – Current Interventions* will also be completed.

All new maps should use the same legends as those used for earlier maps. All newly created documentation material (data forms, maps and photos) must be placed in the same mosaic archive folder as the previous documentation. New data forms, new maps and new photos should be grouped together by maintenance campaign.

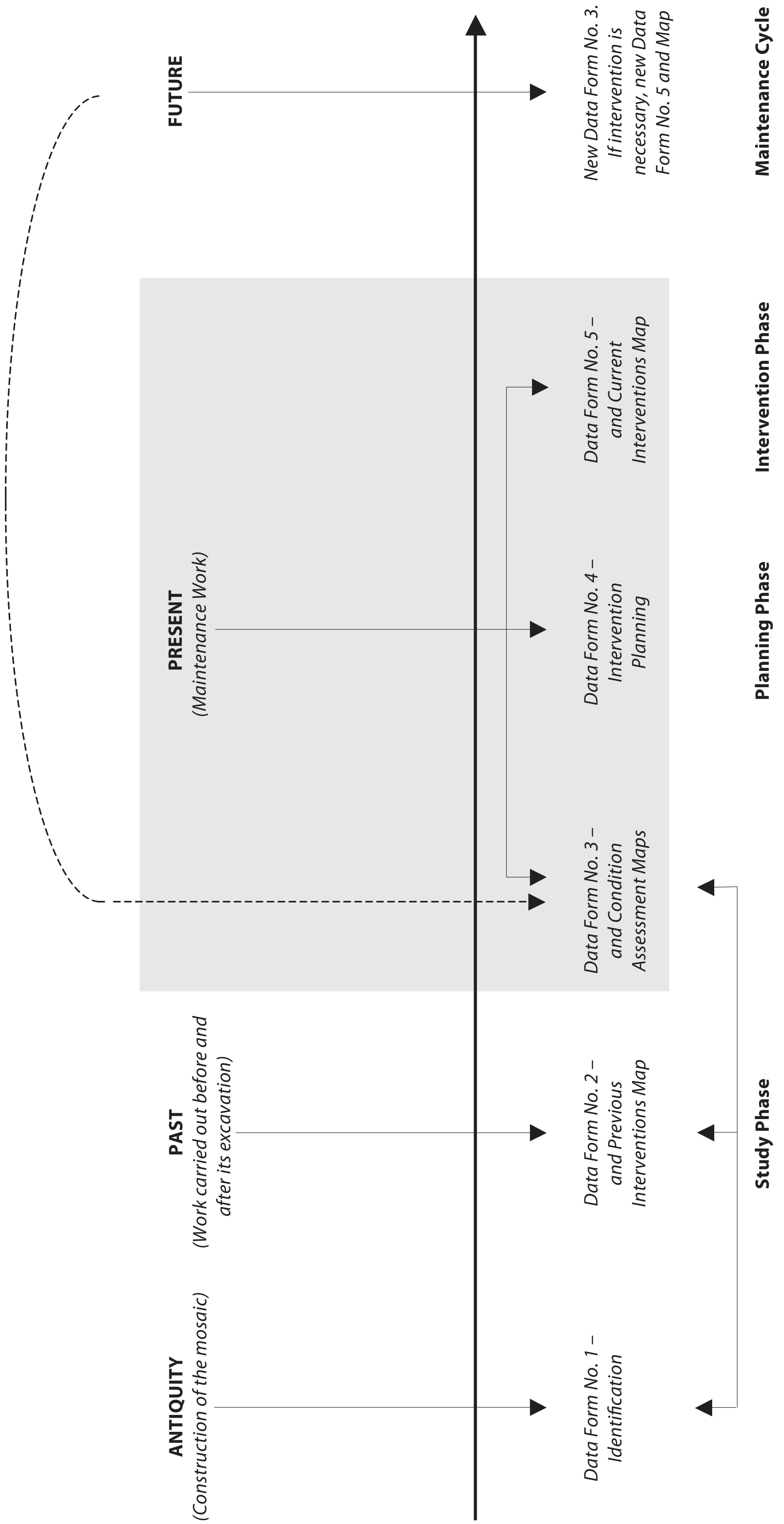

FIGURE 3 The maintenance process and its documentation through time

CHAPTER 2

MAKING BASES AND MAPS FOR GRAPHIC DOCUMENTATION

Graphic documentation enables the accurate mapping of different types of deterioration on the surface of the mosaic and makes it possible to rapidly assess their extent and to pinpoint the location of interventions.

Graphic documentation can be carried out either by hand, using colored pencils, felt pens, paper, etc., or directly on a computer using specific hardware and software. Only the first, traditional, method will be developed here as it is the most widely accessible. Indeed, creating graphic documentation directly on a computer requires specialized computer training.

BASES

Creating a base is the first step in graphic documentation. Copies of the base or transparent sheets superimposed onto the base are used to make all the maps.

There are two types of bases:

- Base drawing
- Base photograph

A base drawing is a drawing of the mosaic. A base photograph is a photograph of the mosaic. Each type of base can be obtained through different techniques (Table 1).

Table 1 Steps in the Graphic Documentation Process

Type of base	Method to produce a base	Media on which the maps are drawn	Types of maps
Drawing (base drawing)	Set up a regular grid of strings onto the mosaic and draw the mosaic directly to scale using graph paper based on measurements of the mosaic taken using the grid	Photocopies of the base or Sheets of tracing paper or a transparency film overlaid on the base	Previous Interventions maps Condition Assessment maps Current Interventions maps
	Photograph the mosaic in a single frame or by sectors and draw the mosaic on a transparent sheet overlaid on the single photograph or on the photomontage		
	Obtain a copy of a drawing of the mosaic taken from a book or an archive		
Photograph (base photograph)	Take a single photograph of the mosaic		
	Photograph the mosaic by sectors with a digital camera and make a photomontage of these images on the computer		
	Obtain a copy of a photograph of the mosaic taken from a book or an archive		

Base drawing

- *Measured drawing* (page 48)

  A base drawing can be obtained directly by setting up a regular grid of strings onto the mosaic and by drawing the mosaic directly to scale using graph paper based on measurements of the mosaic taken using the grid.
- *Traced drawing* (page 51)

  A base drawing can be obtained indirectly from a montage of photographs or a single photograph. To make a montage, the mosaic is photographed sector-by-sector and these photographs are assembled to create a single image. The mosaic is then drawn on tracing paper that is laid over the photographic montage or single photograph, producing a drawing of the mosaic.
- *Existing drawing*

  A copy of an existing drawing of the mosaic, found in a book, in archives or given by the archaeologist or the site director, can also be used. An existing drawing might have to be modified if it is outdated and no longer exactly corresponds to the mosaic's current condition, due to more extensive lacunae for example. It is also important to note the provenance and date of the drawing.

Base photograph

- *Single photograph* (page 52)
  A base photograph can be obtained by taking a photograph of the mosaic. The entire area of the mosaic being documented must be visible in a single photo. If this single photo is digital, the image can be rectified later with a computer: that is, some deformations can be corrected to make the image appears closer to reality, using image-processing software such as Adobe Photoshop or GIMP.
- *Digital photomontage* (see page 54 and *Photomontage of Digital Photographs*)
  A montage of digital photographs can be assembled by taking photographs sector-by-sector of the mosaic with a digital camera. Rectifying and then putting these photos together with an image-processing software such as Adobe Photoshop or GIMP, will produce a complete single image of the entire mosaic.
- *Existing photograph*
  A copy of an existing photograph found in a book, in an archive, or given by the archaeologist or the site director can also be used. An existing photograph might have to be modified if it is outdated and no longer exactly corresponds to the mosaic's current condition, due for example to more extensive lacunae. It is also important to note the provenance and date of the photograph.

The choice between the two types of bases (drawing or photograph) will depend on the work environment and the characteristics of the mosaic. A base drawing does not require specialized equipment, only a pencil, millimeter graph paper and measuring tapes are necessary. For a very large mosaic, it may be easier to draw it rather than create a photomontage. Moreover, a drawing remains better conserved over time than a photograph.

A base photograph is easier and faster to obtain for a smaller mosaic or for a mosaic with an intricate design that is difficult to draw. A photograph provides a more detailed view of the entire surface. A base photograph is therefore more appropriate for a mosaic that does not have a design, where the tesserae themselves must be used as reference points.

MAPS

Once a base drawing or photograph has been created for the mosaic, it is used to make maps. Each map records with colors and symbols the position of various types of information related to the mosaic such as previous interventions, conditions and current interventions (page 60).

Whatever type of base is used, the maps can be drawn in two different ways:

- *Drawing directly on a copy of the base*
  The information about the mosaic is directly recorded on a copy of the base drawing or photograph using color pencils or felt pens.
- *Drawing on a transparent sheet overlaid onto the base*
  The information about the mosaic is recorded on a sheet of tracing paper or of transparency film placed over the base using appropriate pens or pencils.

The maps directly drawn on a copy of the base will be much more readable if a base drawing is used, but they will be more precise if a base photograph is used. Generally, it is preferable to draw the maps directly on a copy of the base rather than on a transparent sheet.

Legends

To be read, each map must have a legend. A legend is an explanatory list of the colors and graphic symbols used to draw the data recorded on the map. For example, the color red can be used to represent detached tesserae, while green hatching can be used to record the presence of micro-organisms. A legend is established prior to recording data on the map. If the legend is on a separate sheet, it must always be attached to the map as a reference in the future. The legend can also be placed on the edges of the map itself if there is enough space available to list all the information recorded on the map.

It is advisable to always use the same legend for each type of map (condition assessment maps for example) to facilitate the comparison between the maps of two mosaics from the same site, or from two different sites, or between the maps of different maintenance cycles of the same mosaic.

A list of materials needed for the documentation of mosaics is provided in Appendix A (page 124).

MAKING A BASE DRAWING DIRECTLY USING A GRID

Equipment

- Soft brush
- String
- Equipment to keep the strings taut (nails, wooden planks, stones, etc.)
- Folding ruler, retractable measuring tape, reel measuring tape
- Large wooden framing squares (to check right angles when setting up the grid)
- Drafting triangle
- Drawing board
- Graph paper
- Tracing paper
- Masking tape
- Pencil and eraser
- 0.1 or 0.2 ultra-fine point pen and razor blade
- Compass
- Colored sticker dots

Steps (Figure 4)

Remove dirt and sand from the mosaic surface with a soft brush, if it is possible to do so without damaging it.

Set up a grid over the mosaic by stretching strings across it at regular intervals (for example, 50 cm) to create squares. The grid squares must always have 90º angles (right angles) and therefore, the strings must be placed using a large wooden framing square. The strings can be fixed to the ground with nails in areas devoid of tesserae or original mortar; otherwise they must be attached to stones, wooden planks or by other means that do not damage the mosaic.

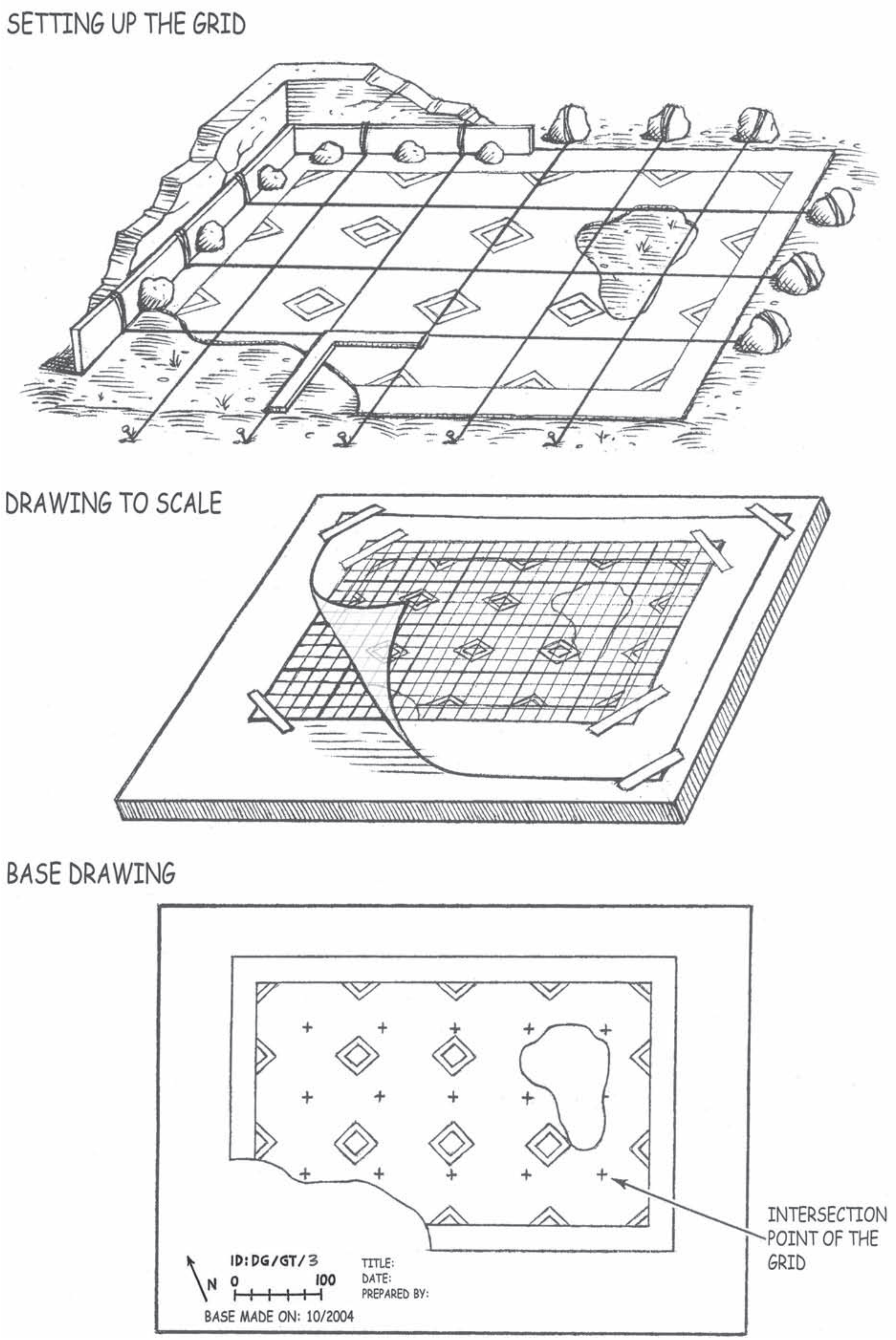

FIGURE 4 Measured drawing using a grid

Attach a sheet of graph paper to the drawing board with masking tape and put a sheet of tracing paper over it. Choose a scale for the drawing according to the size of the mosaic and the paper format used (A3 or A4). A scale of 1:10 or 1:20 (1 cm in the drawing to represent, respectively, 10cm or 20cm in reality) is often advisable. With a pencil, **draw** on the tracing paper **the outline of the mosaic, its simplified design and the outline of the walls of the room**, if they are close by. The mosaic must be drawn square by square, by taking measurements of the mosaic using the grid and transferring them, to scale, onto the tracing paper using the graph paper grid.

If the mosaic is large, it can be **divided into sections**. Each section of the base is then drawn on a separate sheet. These sections and their dimensions will be noted on the sketch of the mosaic on *Data Form No. 1 – Identification*. Each section will be numbered in succession (1, 2, 3, 4, etc.).

Overlay a second sheet of tracing paper onto the first one with the original pencil drawing, and, with a 0.1 or 0.2 ultra-fine point pen, **transfer the drawing** onto the second sheet by **retracing the outline** made on the first tracing paper sheet. If a second sheet of tracing paper is not available, turn over the first sheet, and retrace the original drawing with a pen on the reverse side, then erase the pencil drawing on the front of the tracing paper sheet.

During the study phase, the grid can be left in place on the mosaic to help draw the maps. If one wishes to remove the grid, it is advisable beforehand to **place color sticker dots** on the mosaic surface where the strings intersect and to mark the same points on the drawing base to create reference points.

Label the base drawing (Figure 4, *Base Drawing*) with the following information:

ID: [Mosaic ID]	*Always write the Mosaic ID on the base*
Base made on: [Date]	*Always write on the base the date it was made*
Title:	*Leave empty on the base*
Date:	*Leave empty on the base*
Prepared by:	*Leave empty on the base*

Also add the **graphic scale** (page 58) and an **arrow indicating North**.

MAKING A BASE DRAWING INDIRECTLY FROM A PHOTOGRAPH

Equipment

- Photograph on paper
- Drawing board
- Masking tape
- Tracing paper
- Pencil and eraser
- 0.1 or 0.2 ultra-fine point pen and razor blade

Steps

Attach the photograph to the drawing board with masking tape. Attach in the same manner **a sheet of tracing paper** over the photograph. On the sheet of tracing paper **trace the outline of the mosaic, its simplified design and the outline of the walls of the room**, if they are close by, with a pencil.

Overlay a second sheet of tracing paper onto the first one and, with a 0.1 or 0.2 ultra-fine point pen, **transfer the drawing** onto the second sheet **by retracing the outline** of the original pencil drawing made on the first tracing paper sheet. If a second tracing paper sheet is not available, turn the first sheet over, and retrace the original drawing with a pen on the reverse side, then erase the pencil drawing made on the front of the tracing paper sheet.

Label the base drawing (Figure 4, *Base Drawing*) with the following information:

ID: [Mosaic ID]	*Always write the Mosaic ID on the base*
Base made on: [Date]	*Always write on the base the date it was made*
Title:	*Leave empty on the base*
Date:	*Leave empty on the base*
Prepared by:	*Leave empty on the base*

Also add the **graphic scale** (page 58) and an **arrow indicating North**.

MAKING A BASE PHOTOGRAPH FROM A SINGLE PHOTOGRAPH

Single photograph

Equipment

- Soft brush
- Digital camera
- Stepladder, short ladder or other prop to take pictures from above
- Metric photo scale
- Small chalkboard and white chalk
- Compass
- *Photograph Log* and pen

Steps

Remove dirt and sand from the mosaic surface with a soft brush, if it is possible to do so without damaging it.

Place within the image frame of the photograph, but outside the mosaic surface, the **metric photo scale** and **the chalkboard** where the mosaic ID and the date are written. **Indicate North** on the chalkboard or with an arrow next to it.

Adjust the zoom lens of the camera (page 62) so that the entire mosaic, the metric photo scale and the chalkboard are visible in the photo frame. To minimize subject deformation, the photograph should be taken from an elevated position, as vertically as possible from the center of the mosaic **by using a stepladder or a short ladder** or other prop.

If the camera is used in manual mode, adjust also the shutter speed and the lens aperture so that every area of the image is in focus (page 67).

Take the photograph and add the information concerning it on the *Photograph Log* (page 33).

Base photograph from a single photograph

Equipment

- Photograph stored in the memory card of a digital camera
- Computer
- Word-processing software (such as Microsoft Word for example)
- Image-processing software (such as Adobe Photoshop for example), if available
- Printer and paper sheets in A4 or A3 format

Steps

Upload the digital photograph from the camera to the computer. **Check** that the image is correctly framed and in focus and rotate it, if need be, so that it is in the proper orientation (see *Transfer and Archiving of Digital Photographs*). If an image-processing software such as Adobe Photoshop is available, use it to **rectify the photograph** (see *Photomontage of Digital Photographs*). **Rename** the photograph and **file** it in the digital folder corresponding to the room where the mosaic is, following the digital file archiving method (page 36).

Insert the photograph into a word-processing document using a software such as Microsoft Word (see *Layout of Digital Photographs*) and **label the base photograph** with the following information:

ID: [Mosaic ID]	*Always write the Mosaic ID on the base*
Base made on: [Date]	*Always write on the base the date it was made*
Title:	*Leave empty on the base*
Date:	*Leave empty on the base*
Prepared by:	*Leave empty on the base*

The base photograph should be **printed** in color in A4 format or, if it is possible and needed, in A3 format. Add by hand the **graphic scale** (page 58) and an **arrow indicating North** (Figure 5, *Base photograph*), if they are not present within the frame. The color print should be kept as the original base, for eventual **photocopying** in black and white to make the maps. It is also possible to directly print bases from the computer in black and white for the maps.

If a computer linked to a printer is not available, it is possible to print the photograph directly from the camera in a specialized shop. In this case, all the information detailed above should be written with a pen to complete the base photograph.

MAKING A BASE PHOTOGRAPH FROM A PHOTOGRAPHIC MONTAGE

Photographic survey to make the photographic montage

Equipment

- Soft brush
- Folding ruler, retractable measuring tape, reel measuring tape
- Large wooden framing squares (to check right angles when setting up the grid)
- Colored sticker dots
- Digital camera
- Stepladder, short ladder or other prop to take pictures from above
- Metric photo scale
- Small chalkboard and white chalk
- Compass
- *Photograph Log* and pen
- Sheet of paper, pencil and eraser

Steps (Figure 5)

Remove dirt and sand from the mosaic surface with a soft brush, if it is possible to do so without damaging it.

Divide the entire mosaic surface in square sectors of identical size using the measuring tape and the wooden framing square, **marking the sector angles** with colored sticker dots on the surface of the mosaic.

The size of the sectors should be chosen according to the camera lens used and the work environment. Set the zoom lens to wide angle to have the widest possible framing. If it is possible to photograph each sector from a 2-meter height while being located 2 meters away from the center of the sector (Figure 5, *Taking the photograph*), square sectors measuring 120 cm × 120 cm are appropriate. If it is possible to take the photographs from a height of more than 2 meters or if the camera can offer a wider framing, the size of the squares can be increased and therefore their number can decrease.

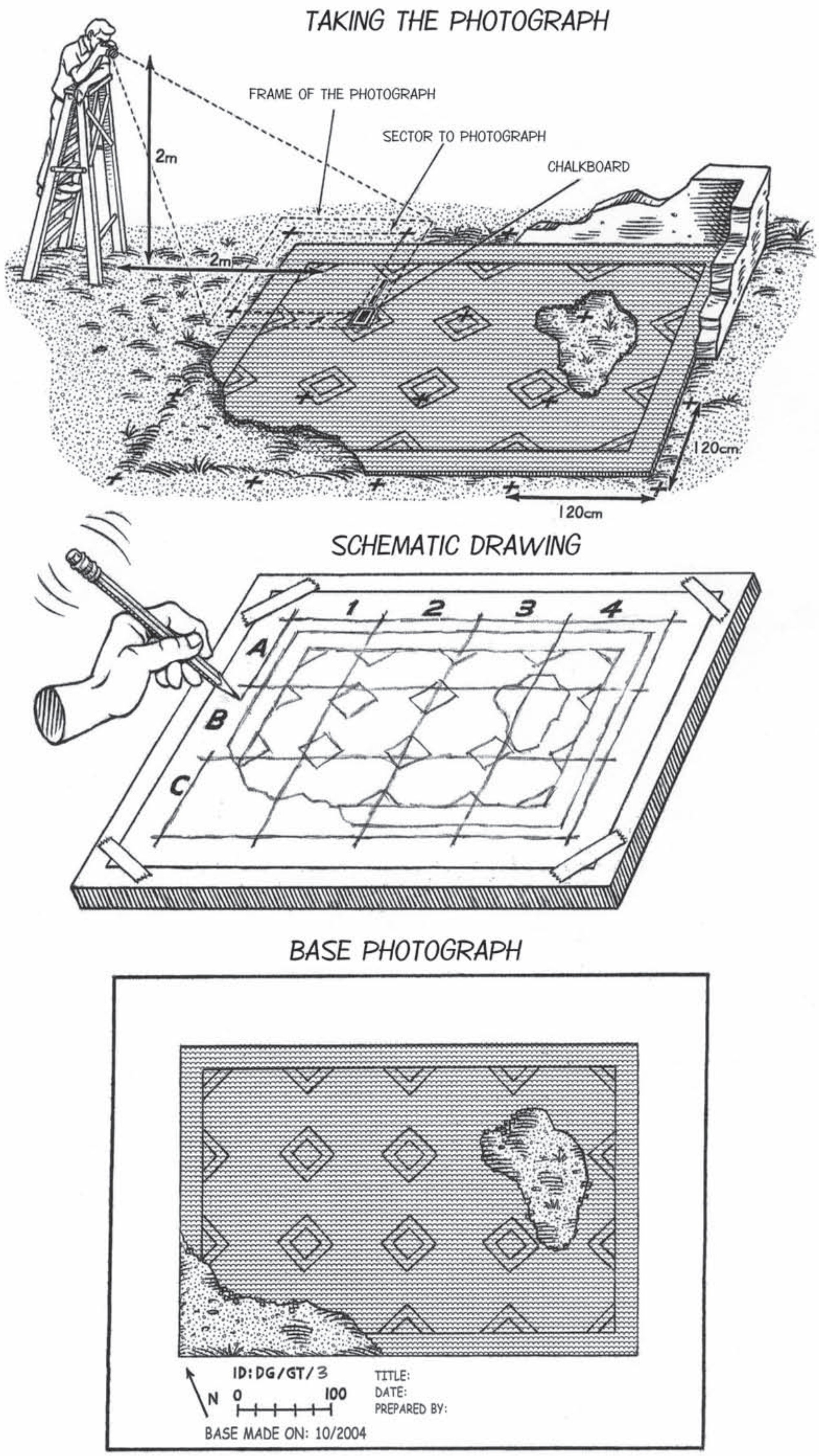

FIGURE 5 Base photograph by photo montage

Make a schematic drawing of the room and mosaic. Indicate on the drawing the sectors created with sticker dots and write down their dimensions. In this sector grid, assign a number in order to each vertical column starting with 1, and a letter from A to Z to each horizontal row. Each picture will be identified by the letter-number code corresponding to the photographed sector. For example: The photograph of the sector located at the top of the first column and in the first row to the left will be referred to as A1. Photo B1 will be located directly underneath photo A1; photo A2 will be the photograph to the right of A1, etc. (Figure 5, *Schematic drawing*)

Before taking each photograph, **place** within the photo frame but outside the sector being photographed the **metric photo scale** and **the chalkboard** on which the mosaic ID and the sector letter-number code are written. **Indicate North** on the chalkboard or with an arrow next to it.

Adjust the camera zoom (page 62) so that the entire sector to be photographed marked by the sticker dots is visible in the photo frame. Also include in the frame a part of each adjacent sector where the chalkboard and the metric photo scale are placed.

If all the photographs are taken from the same distance, the **zoom** must be adjusted for the first photograph and must **be kept the same** throughout the entire photographic survey of a mosaic.

If the camera is used in manual mode, adjust also the shutter speed and the lens aperture so that the every area of the image is in focus (page 67).

Photograph the mosaic, one sector after another, following the previously established divisions, always keeping the camera at the same distance from the mosaic surface from one photograph to the next. To minimize subject deformation, the photograph should be taken from an elevated position, as vertically as possible from the center of the sector to be photographed. However, image deformation can be corrected on a computer after shooting using an image-processing software such as Adobe Photoshop (see *Photomontage of Digital Photographs*).

List the photographs on the *Photograph Log* as they are taken, carefully noting the letter-number code of the photographed sector.

Base photograph from a photographic montage

Equipment

- Photographs stored in the memory card of a digital camera
- Computer
- Word-processing software (such as Microsoft Word for example)
- Image-processing software (such as Adobe Photoshop for example) if available
- Printer and paper sheets in A4 or A3 format

Steps

Upload the digital photographs from the camera to the computer and **file** them in a new folder within the folder named for the room where the mosaic is located. **Rename** the photographs using for the "note" part of their name, the letter-number code of the photographed sector corresponding to the schematic drawing of the mosaic (see *Transfer and Archiving of Digital Photographs*).

Rectify each photograph, then **create a photomontage** of the entire mosaic surface using an image-processing software such as Adobe Photoshop (see *Photomontage of Digital Photographs*). A photomontage is a single photograph created by putting together at least two photographs.

Insert the photomontage into a word-processing document using a software such as Microsoft Word (see *Layout of Digital Photographs*) and **label the base photograph** with the following information:

ID: [Mosaic ID]	*Always write the Mosaic ID on the base*
Base made on: [Date]	*Always write on the base the date it was made*
Title:	*Leave empty on the base*
Date:	*Leave empty on the base*
Prepared by:	*Leave empty on the base*

The base photograph should be **printed** in color in A4 format or, if it is possible and needed, in A3 format. Add by hand the **graphic scale** (page 58) and an **arrow indicating North** (Figure 5, *Base Photograph*). The color print should be kept as the original of the base for eventual **photocopying** in black and white to make the maps. It is also possible to directly print bases from the computer in black and white to make maps. If a printer is not available, it is possible to copy the photomontage onto a USB memory key or on a CD/DVD and to print it in a specialized shop. In this case, all the information detailed above should be written with a pen to complete the base photograph.

DRAWING THE GRAPHIC SCALE OF A BASE DRAWING OR PHOTOGRAPH

The **scale** of a drawing or photograph is the ratio between the distance between two points measured in reality and the distance between the same two points measured on the drawing or the photograph. The scale drawn on a base drawing or photograph is called a graphic scale. It is a bar divided into intervals, with a zero at the left end, and a dimension, often expressed in meters, at the right end. It enables one to calculate the actual distance on the mosaic from a drawing or a photograph of the mosaic.

There are two methods to make a graphic scale:

- **Locate on the mosaic two points a meter apart** which are also visible in the drawing or the photograph of the mosaic. On the drawing or the photograph, **find the two points and measure the distance** between them using a ruler. **Draw** on the base drawing or photograph **a straight line, the length of which is the distance** just measured with the ruler. Mark at the ends of this line the values 0 to the left and 1 meter to the right. This bar is the representation of the length of one meter in the actual mosaic. The distance of 0.5 m can also be indicated by a tick mark located in the middle of the bar as shown below (Figure 6).

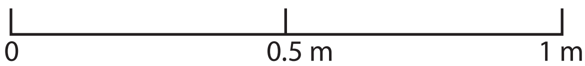

FIGURE 6 Graphic scale

- **Measure the distance between two points on the mosaic** that are also identifiable on the drawing or the photograph. For example, measure the total length of one side of the mosaic or the distance between two decorative motifs. A long enough distance should be selected (more than 1 meter if possible). **Measure the same distance on the drawing** or the photograph. **Divide the distance on drawing by the distance on the mosaic**, expressing both of them with the same unit of measure (centimeters or meters). Multiply the result of the division by 100. This final number is the number of centimeters measured on the drawing that correspond to 1 meter on the actual mosaic: this will enable the drawing of the graphic scale. **Draw** on the base drawing or photograph **a straight line, the length of which is the final number of centimeters** just obtained by the

previous calculation. Mark at the ends of this line the values 0 to the left and 1 meter to the right. The scale bar can be further subdivided into segments to indicate intermediate measurements.

Calculation example: the actual width of the mosaic is 2.4 m, that is 240 cm, and the width of the mosaic drawn on paper is 23 cm. First, divide the width of the mosaic on the paper by its width in reality, which is 23:240 = 0.095. Then, multiply the result by 100, which is 0.095 × 100 = 9.5. This means that 9.5 cm measured on the drawing are equal to 1 meter measured on the actual mosaic. Finally, draw a line of 9.5 cm on the base drawing and write at its ends 0 and 1 meter (Figure 7).

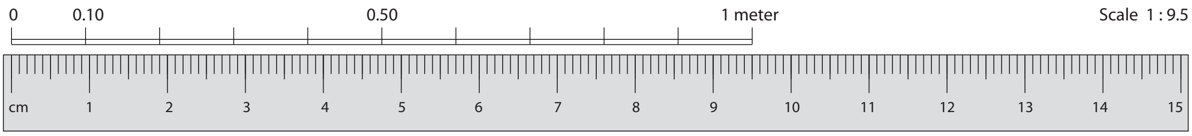

FIGURE 7 Graphic scale

MAKING A MAP

Equipment

- Copies of the base drawing or photograph
  or
  Base and sheets of tracing paper or transparency film (if it is not possible to make copies of the base)
- Drawing board
- Pencil and eraser
- Colored pencils or felt pens for the copies of the base and the sheets of tracing paper
  or
  Permanent markers for transparencies
- White corrector fluid

Steps

- If the maps are to be drawn directly on copies of the base drawing or photograph: **Photocopy the base** (previously printed in color) on A4 or A3 paper, reducing it or enlarging it as needed. For a base photograph, the copies should be **as light as possible** while keeping the mosaic visible, so that the colored mapping is legible. It is also possible to directly print bases from the computer in black and white to make plans.
- If the maps are to be drawn on separate transparent sheets independent from the base: **Overlay the sheets of tracing paper** or transparency film **onto a black and white copy of the base**. It is easier to work on a black and white base, consequently a photocopy of the base printed in color should be made or the base should be directly printed in black and white.

Write the following information on each copy of the base or each transparent sheet overlaid onto the base, filling out the captions left blank on the base:

- The title of the map; for example, Current Interventions Map
- The date when the map was drawn; for example, May 2004
- The names of the people who created the map

- In the case of a transparent sheet, it should be identifiable without the base. The words "ID:", "Title:", "Date:", "Prepared by:" which are on the base should be rewritten onto the transparent sheet, and most importantly, the complete mosaic ID must be included.

Draw the map on a copy of the base or on a transparent sheet placed over the base, using different colors and graphic symbols already defined in the legend.

When creating the study phase maps (*Previous Interventions Map* and *Condition Assessment Maps*), draw one type of data for the entire mosaic surface before proceeding to the next type of data. For the *Current Interventions Map*, it is recommended to record on the map all work as soon as it is completed at the end of each workday.

A **legend must always be kept with its corresponding map** or be drawn on the map itself, as a map cannot be understood without a legend.

CHAPTER 3

THE USE OF A CAMERA AND COMPUTER IN DOCUMENTATION

CAMERA

A camera consists of a **body** and a **lens**. The light coming from the photographed object enters the camera body through the lens. Inside the body, a light sensitive surface captures and records this light. There are several types of photography which can be differentiated by the nature of the light-sensitive surface used. **Traditional photography** uses photographic film; **digital photography** uses an electronic sensor.

Nowadays, traditional cameras are used less and less frequently as it is becoming harder to find film and to develop it. Digital cameras also enable the user to print his/her own photographs using a computer and a printer. Digital photographs can also be displayed on the camera screen immediately, enabling the user to view them immediately.

The camera lens is made of a system of lenses that directs the light inside the camera body, changes the amount of light reaching the sensitive surface and adjusts the focus of the image. The lens system also determines the framing (or field of view), that is, the limits of the visual field recorded by the camera. To record a wider field of view, so-called wide-angle lenses are used; to record a narrower field of view or to obtain close-up images, normal lenses or telephoto lenses are used. A **zoom** is a lens that has a field of view which can be changed, allowing one to obtain different framings with the same lens, ranging from a wide field of view, to a narrow field of view that brings the objects photographed closer. Some cameras have a **fixed lens** that cannot be separated from the body, others have an **interchangeable lens**.

Before taking a photograph, a number of settings must be adjusted on the camera. **Automatic cameras** automatically adjust one or more functions, while on **manual cameras** these settings are adjusted by the photographer. Modern good-quality cameras usually have both a manual and an automatic mode.

So-called “**compact**” cameras are generally smaller cameras with a fixed lens (often a zoom), the operation of which is often completely automatic. So-called “**reflex**” cameras are generally larger cameras with interchangeable lens which allow manual adjustment of many settings (Figure 8).

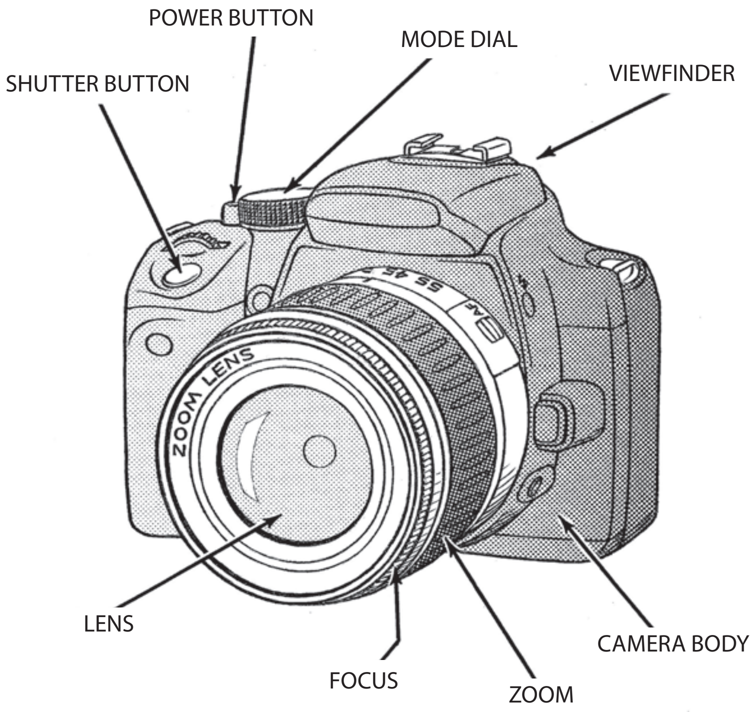

FIGURE 8 Reflex digital camera

In view of current developments in photography, only the use of digital cameras will be addressed here.

Any digital camera, regardless of brand or model, has a memory card and a battery with its charger. It also comes with an instruction manual, a small booklet which should be read before using the camera in order to properly adjust the camera settings.

In a digital camera, the light coming from the object to be photographed is captured by an electronic sensor that converts it into a digital image. The image is a digital file that is saved on the memory card inside the digital camera. These images can later be uploaded to a computer (see *Transfer and Archiving of Digital Photographs*).

A digital camera automatically assigns a name to every digital photograph. This name is generally made of a sequence of letters (which varies depending on the camera type) followed by an ascending number. The number of a digital photograph can be found when the image is displayed on the camera screen in view (or playback) mode (button ▶) and when the option to display the image information has been selected (Figure 9). This photograph number is also visible when the photograph is uploaded to the computer. It is this digital photograph number that will be used to record the photograph on the *Photograph Log* and on the *Photograph Map*.

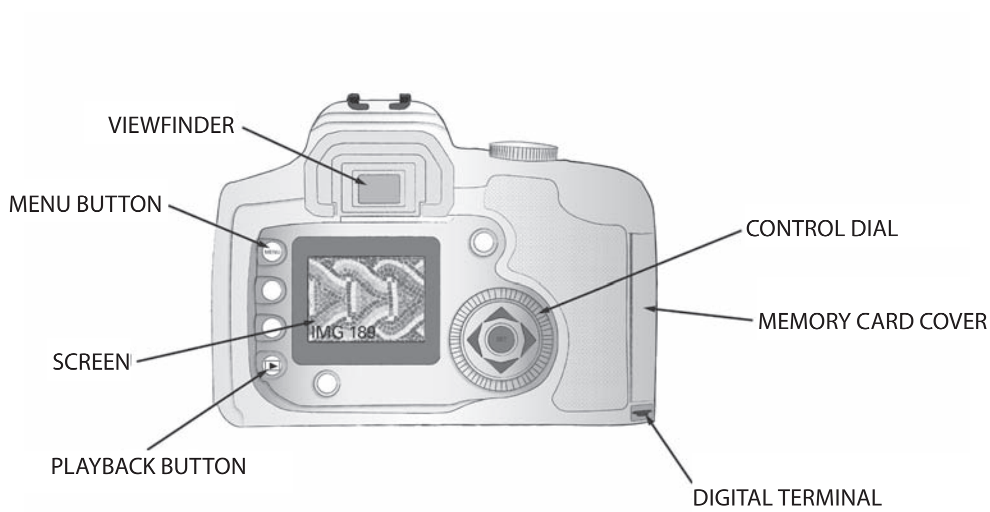

FIGURE 9 Digital reflex camera seen from the rear

Settings of a digital camera

Whether the digital camera is automatic or manual, a number of general settings should be adjusted before its use. These settings are modified by pressing the **Menu button** of the camera and by following the instructions of the manual (see Figure 10).

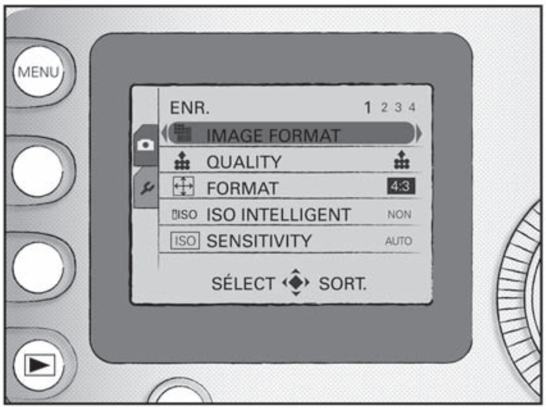

FIGURE 10 Digital camera screen showing main menu

The advice given below covers only the most basic and simple settings, but they are sufficient for documentation required during the mosaic maintenance process.

Initial settings to be chosen before using the camera:

- **Display language:** You can chose the language used to display menus on the screen of the camera from a list of the most common languages.
- **Date and time:** The camera's date and time should be checked before starting to take photographs to verify that they are set correctly. Indeed, the date and the time when the photograph is taken are recorded together with each digital image. Therefore, it is important that they are correct for the archiving of the photographs.

The most important image-related function settings:

- **Image format:** Some cameras offer a choice of image formats which have different width to height ratio. The [4:3] format is the most common and it is suited to the needs of documentation for mosaic maintenance. It corresponds to the 24 mm × 36 mm format of a traditional photographic film.

- **File type:** Some cameras can save photographs in two different types of digital files, in JPEG or in RAW format. The JPEG format is the most appropriate because it is a compressed image format, therefore the file size is smaller.
- **File size:** A digital image is made up of many very small squares called pixels. The number of pixels that make up the images can be chosen. The more pixels a photographic image has, the finer and more defined it will appear on a computer screen, or when printed. This difference is not visible on the screen of the camera because it is too small. However, the more pixels an image has, the "heavier" the digital file will be, that is, the larger its size will be. Files that are too heavy can cause problems when they are uploaded in large numbers to a computer or when working on them with software. In general, for documentation, a [3M] photograph size (M: megapixels) is appropriate. For photographs used to make a photomontage, a [1M] size, or a maximum size of [2M], is sufficient.
- **Image-recording quality:** Some cameras offer a choice between different qualities of JPEG images. Quality refers to the compression rate of the image. The more compressed the image is, the less accurate the image will be, and the less it reflects the reality of what is seen, but the digital file will be smaller. For mosaic documentation, it is sufficient to choose the medium image quality among those proposed by the camera.
- **White balance:** This feature enables one to correct the effects of ambient lighting so that the white color is reproduced as realistically as possible, without for example reddish or bluish effects. When taking photographs under natural daylight, in the outdoors, the automatic mode is appropriate. It corresponds to the setting [AWB] (Automatic White Balance).
- **Sensor's sensitivity to light:** The sensitivity of the sensor is measured in ISO. Low ISO settings (ISO 100 for example) produce sharper images but require more light because the sensitivity is lower. High ISO settings (ISO 6400 for example) allow one to take a picture with less light because the sensitivity is higher, but the image will be grainier. When taking photographs outdoors, the sensitivity can be set to automatic mode [AUTO].

The general settings explained above should be applied to all the photographs taken. In addition, before taking each picture, the following adjustments should be made:

– **framing** to get the desired field of view,

– **focus** of the subject to get a sharp image

– **shutter speed** to change the amount of light entering the camera when a photograph is taken,
– **lens aperture** to change the amount of light entering the camera when a photograph is taken; this changes the depth of field, the distance between the nearest point and the furthest point in reality which are both in focus in the image.

- **Framing** can be modified, without the photographer needing to move, if the camera has a **zoom** or by changing lens. In the first case, by adjusting the zoom lever for compact cameras, or by turning the zoom ring for reflex cameras, it is possible to obtain a wider framing for more general views, or a closer framing to take pictures of details. If several lenses are available, a wide angle lens (28–35 mm) should be used to take general photographs, and a normal lens or a telephoto lens (40–80 mm) should be used for the close-up photographs.

Fully automatic cameras or cameras set in automatic mode:

- The **focus** of the subject, the **shutter speed** and the **lens aperture** are set automatically when the shutter button is pressed halfway. All settings are then correct and the shutter button can be pressed completely to **take the photograph**.

Semi-automatic or manual cameras:

- The **focus** of the subject can be adjusted automatically by almost all cameras. If this function, called autofocus, exists it is advisable to use it by setting the focus mode switch, located on the lens, to [AF]. The camera then automatically focuses when the shutter button is pressed halfway. The focus can be adjusted manually by turning the focus ring, which is located on the part of the lens farthest away from the camera body, until the subject, seen through the viewfinder or the camera screen, is sharp.

The **shutter speed** and the **lens aperture** are two settings that are linked, and they allow one to adjust the exposure. A good exposure is obtained through a proper combination of shutter speed and lens aperture.

Many cameras adjust the exposure semi-automatically. The photographer chooses one setting, either the shutter speed (mode [Shutter Priority]) or the lens aperture (mode [Aperture Priority]),

and the camera adjusts the other automatically to get the correct exposure. In fully manual mode, the photographer adjusts both the speed and the aperture.

- The **shutter speed** is related to the length of time during which the camera's sensor is exposed to light. The duration of the exposure is counted in seconds. A short duration will be a few fractions of a second (less than one second), a long duration will be several seconds. A shutter speed of 1/60 or 1/125 of a second is recommended. Shutter speeds slower than 1/60 of a second (that is, numbers smaller than 60 in the denominator) should not be used without a tripod, because it is not possible to keep a hand-held camera stable for the time required to obtain a sharp picture.
- The **lens aperture** is related to the size of the hole that lets the light enter and reach the sensor when a picture is taken. The value of the aperture controls the depth of field, that is, the size of the sharpness zone. This is the distance between the closest point and the furthest point in reality, which are both sharp in the photograph. The size of the aperture is given by the letter "f" followed by a number. The smaller the aperture is (corresponding to a high "f", such as f-22), the greater the depth of field will be. The larger the aperture is (corresponding to a small "f", such as f-2.8), the smaller the depth of field will be. If one wants to photograph an entire floor mosaic in a single image (page 52), it is strongly recommended that an aperture as small as possible (corresponding to a high "f") is used so that the entire mosaic surface is in focus.

When all adjustments have been made, the shutter button is pressed completely to **take a photograph**.

General advice about photography

To take a good photograph, one should consider a number of practical aspects:

- Avoid taking photographs facing the sun.
- Avoid taking photographs of areas that are partly shaded and partly lit, as too great a difference in lighting will not allow the camera to be correctly adjusted for both areas at the same time. Consequently, part of the photograph will be too light or too dark.
- Pay attention to how you frame the image. It should be centered exactly on the area of the mosaic to be photographed and should be tightly framed to avoid the inclusion of other objects in the photograph.

To care for the camera:

- Avoid touching the lens and the screen on the camera body.
- Keep the camera in a closed bag when not taking pictures. It is a fragile object, which is sensitive to dust.
- Frequently upload all digital photographs to a computer. The memory card will also be regularly reformatted by following the instructions in the camera's user manual.
- Do not remove the memory card from the digital camera while the images are being uploaded to the computer.
- Remove the batteries and the memory card when the camera is left unused for a long period of time.

COMPUTER

A computer is made of several components interconnected by cables. A **desktop computer** is generally made of, at least, a central processing unit, a monitor, a keyboard and a mouse (Figure 11).

There are also **laptop computers** that are much smaller and lighter than desktop computers, and can thus be easily transported anywhere. A laptop has the same elements as a desktop computer but they are all integrated into a single object: a flat box that opens, incorporating a central processing unit, a screen, a keyboard, and a mouse which takes the form of a touch pad (Figure 12). At equal performance, a laptop often costs twice as much as a desktop computer. It is also often more fragile.

The **central processing unit** (CPU) housed in the main computer case is the heart of the computer. It is where calculations are performed and data are stored. It contains the **microprocessor** which is the brain of the computer. It processes and circulates information. The

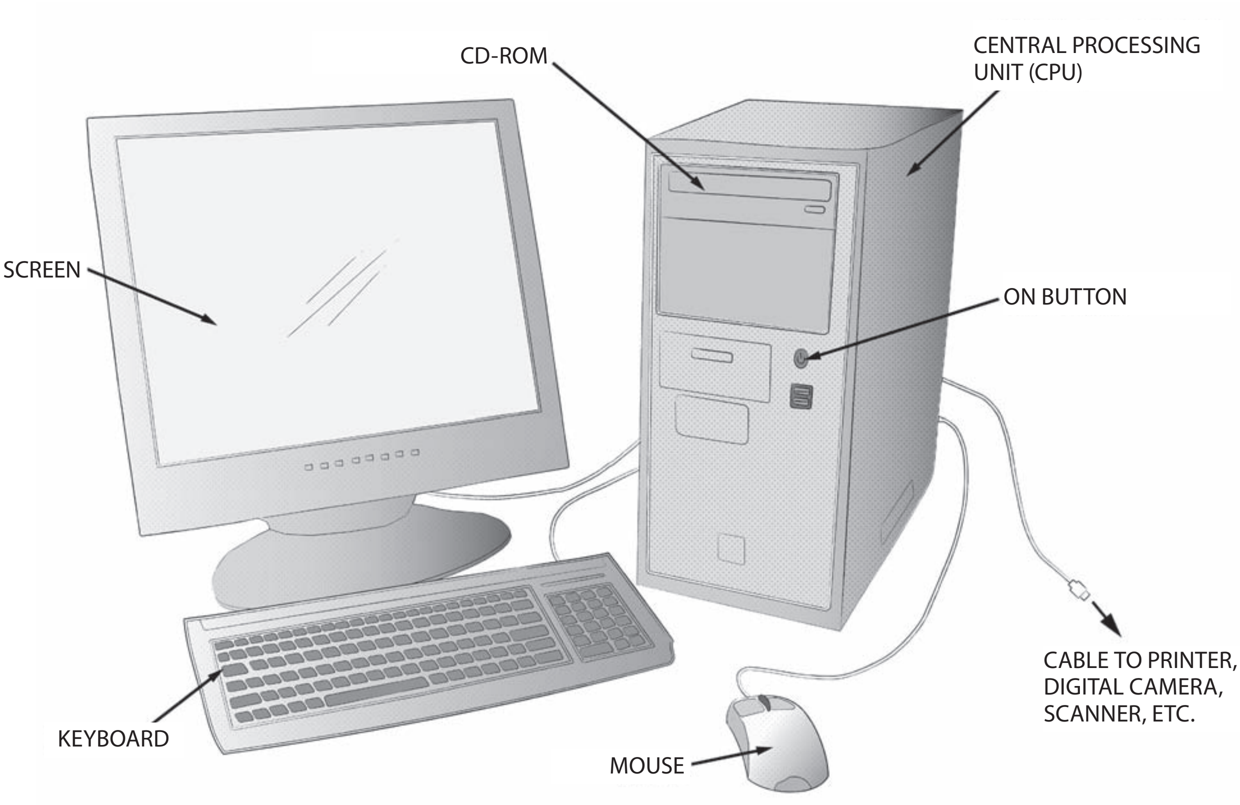

FIGURE 11 Desktop computer

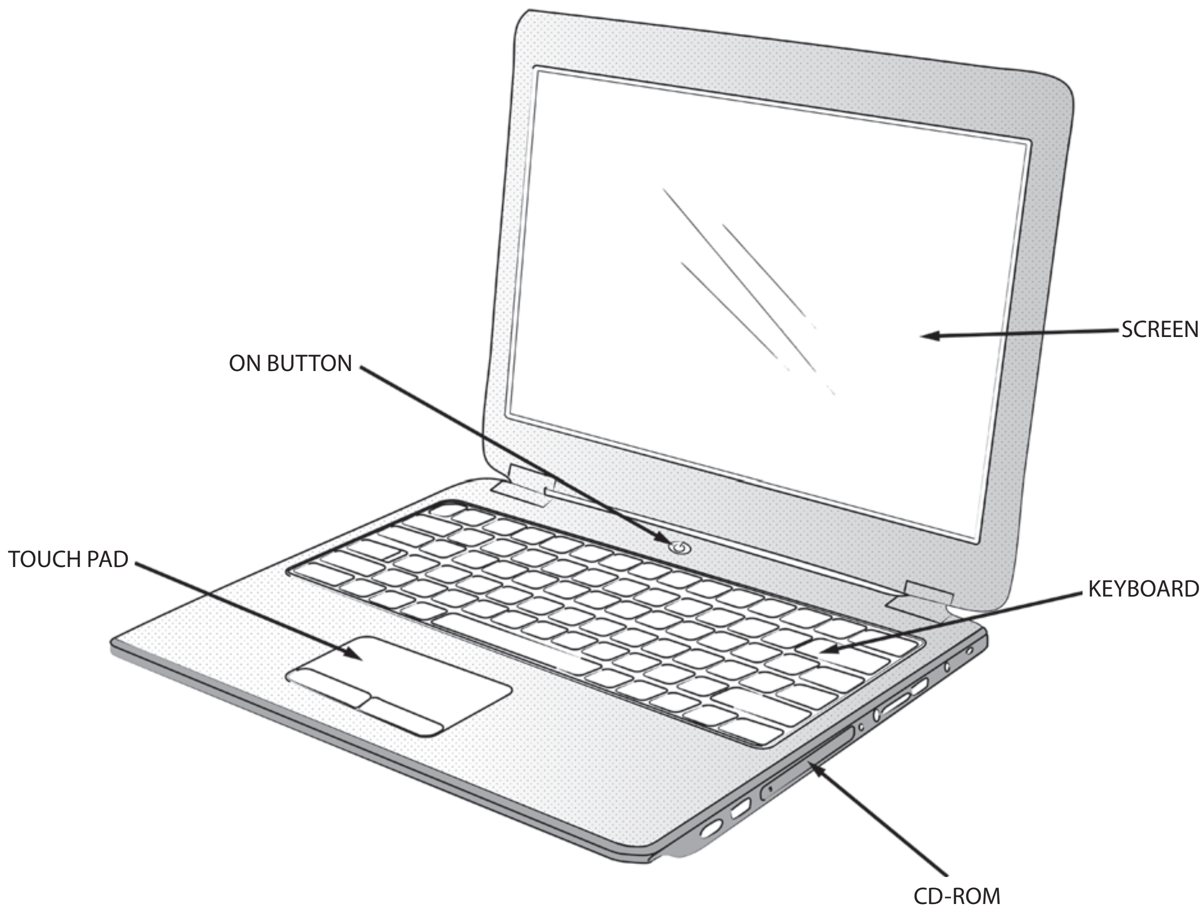

FIGURE 12 Laptop computer

faster the microprocessor performs these tasks, the more powerful the computer is. The CPU also contains the **hard drive**. It is the memory of the computer where all data are stored. Even when the computer is turned off, information remains stored in the hard drive.

To use a computer, one must plug additional elements into the CPU, called **peripheral devices**, which make it possible for a person to communicate with the computer (using a monitor, a keyboard, a mouse, etc.) and to perform specialized tasks (by using a printer, a scanner, a CD-ROM drive, etc.).

The **screen**, or monitor, lets one see what one is doing. The **keyboard** makes it possible to communicate with the computer by writing text, typing commands, etc.

The **mouse** is a small box that is held under the hand. It usually has two buttons on the top, a main button on the left and a secondary button on the right. The action of briefly pressing any button on the mouse is called to **click**. Moving the mouse with one's hand will make a **cursor** on the computer screen move. A cursor is a kind of marker that indicates which area of the screen will react immediately to the instructions that are given to the computer. On most computers the basic appearance of the cursor is a small arrow. By simultaneously pressing a mouse button, it allows one to select objects visible on the screen, and to move them, etc. The cursor can also change its shape: when it becomes a small vertical line in a text, for example, it is then possible to write, change, and delete text.

Laptops have a **touchpad** built into the computer which replaces the mouse. It is usually located under the keyboard and the buttons below serve as mouse buttons. With a touchpad, the cursor is moved on the screen by moving one's finger on the sensitive surface of the pad.

Computers are usually equipped with one or more drivers, often inserted into the main computer case. A **CD-ROM drive** can read information contained in CDs but can also often write (burn) CDs to store data outside of the computer.

Today, virtually every computer also contains a **modem** that can communicate with other computers remotely via a telephone line. It is the modem that enables the user to connect to the **Internet**, either by plugging a cable to the computer or by wireless technology (like Bluetooth or WiFi).

Many other specialized **peripheral devices** can be connected to a computer, always plugged into the CPU, to do specific tasks. For example, a **USB memory key** or **portable hard drive** is used to store computer data outside the computer. A **printer** is used to make paper copies of digital documents and images. A **scanner** is used to create digital documents from real documents, such as a print photograph, a map drawn with colored pencils or a data form completed by hand. A **digital camera** can be plugged into a computer to transfer the photographs from the camera to the hard disk of the computer.

For a computer to work, **software** needs to be installed on the hard drive. A software is a set of computer programs and data that will tell the computer what to do and how to do it. There are two broad categories of software: system software and application software.

A system software, such as the **operating system** of the computer, controls the basic functions of the computer and manages its use with application softwares. Without an operating system like Windows (XP, Vista, 7 . . .), Linux, or Mac OS, application softwares cannot work.

An operating system is like the head of a construction site, who tells the workers (application softwares) what to do, decides in what order things are done, and remembers what has already been done and what remains to be done. He decides which worker has the right to use what tools and when and he tells the workers what the person using the computer wants them to do, etc.

An **application software** is a program that allows the user to do specific tasks. A very common application software is a word-processing software (for example Microsoft Word, OpenOffice Writer). It can write, edit, format and save documents that contain text (letters, reports, etc.). There are many softwares that allow the user to do specific tasks: edit an image (for example Adobe Photoshop, GIMP), surf the Internet (for example Microsoft Internet Explorer, Mozilla Firefox, Google Chrome, Apple Safari), draw a plan, do calculations, etc.

When a computer is turned on, the **desktop** appears on the monitor. The desktop is the presentation screen of the computer. It is made of a large window where there are several **icons** (small pictures) which enable one to directly access, by clicking on them, some software or files. Each user can organize his or her computer desktop as s/he wants. For example, the **trash or recycle bin** is located on the desktop, which is where files that have just been deleted are temporarily stored.

In the bottom left corner of the desktop, a **button**, sometimes called **Start**, enables one to open all the softwares installed on the computer, but also to access various files and folders. It is possible to open several programs and files at the same time. Each will open in a different **window**. Using the Start button, one can also look for a specific file, make many adjustments to the computer, etc. It is also by using this button that the computer is turned off after use. One must never shut down a computer by pressing the power button on the machine; one must always click on the Start button and find the “Shut Down” command.

A **menu** is a list of commands that generally appears in a rectangle and which enables one to do different actions. A menu appears when one clicks with the mouse in a particular area of the screen. One can then select one of the menu commands by clicking on it with the left mouse button. Usually the list of commands in a menu does not change, but there is a particular type of menu, called the **contextual menu**, the contents of which change depending on where the mouse cursor is located. One typically opens a contextual menu by a **right click** of the mouse.

In many softwares, some of the basic menus that contain the most common commands are located in the **control bar** to make them easily accessible. The control bar is located at the top of the software window and contains the names of the basic menus, such as File, Page Layout, View, Help, etc. If you click on one of these names, the corresponding menu opens and the most frequently used commands can be accessed.

A computer can be used at different moments during the documentation process of mosaic maintenance. Data forms (written documentation) can be created and filled out using a word-processing software. Such software also allows one to write reports.

If a digital camera is available, digital photographs can be uploaded to a computer. If a scanner is available, a drawing done by hand can be made into a digital image. A digital photograph or drawing can then be used to create a base photograph or drawing by simply inserting the image onto a page using word-processing software. The page can then be printed on paper. Using a specialized image-processing software, digital photographs or drawings can be edited.

Maps made by hand on paper can be scanned to obtain the same maps in digital form. Maps of the graphic documentation can also be created directly on a computer if the appropriate equipment is available.

A computer then allows one to easily archive all digital documents and images that have been created during the documentation process.

PART II

DETERIORATION AND INTERVENTIONS

CHAPTER 4

DETERIORATION

The deterioration of a mosaic is the process of transformation that leads to the gradual loss of the original qualities and properties of the constituent materials of a mosaic and the separation of its components (tesserae, mortars). The visible deterioration phenomena produced by these transformations are many and can be classified into different types. These phenomena can affect the structure of the mosaic, its surface, as well as the conservation interventions which were carried out on the mosaic in the past. These phenomena are those recorded on *Data Form No. 3 – Condition Assessment*, and on the four condition assessment maps during the documentation of a mosaic (see page 19 and the *Glossary*).

The causes of deterioration of an in situ mosaic are numerous and several causes are often associated with one type of deterioration. Deterioration of a mosaic is generally due to two main categories of factors: those related to the **environment**, especially due to the presence of water, and those related to **human activities**. These deterioration factors will act on the mosaic, but the **inherent properties of the materials** of the mosaic will also influence the rate and extent of its deterioration.

Before intervening on a mosaic, it is therefore also important to understand the causes of deterioration as well as to know the materials which make up a mosaic.

ENVIRONMENT

Climate

The climate of a site, i.e. the weather conditions (rain, sun, snow, temperature, etc.) prevailing in that area, is one of the principle environmental factors. In some climates, changing weather conditions lead to large variations in temperature and humidity each day, but also throughout the

year. The more significant, sudden and frequent these changes are, the more they will lead to the deterioration of the constituent materials of a mosaic (lime mortar, stone, etc.) through different mechanisms. In a more stable climate, these variations will be less significant, slower and not as frequent; consequently, mosaics will suffer less deterioration.

All archaeological sites do not have the same climate and therefore do not suffer the same type of deterioration. The climate of coastal sites, located near the sea, is generally more humid and more stable, but they suffer the adverse effects of salty sea winds and salty sea water that can sometimes seep into the ground. Inland sites generally experience more significant temperature variations between seasons, with hot summers and cold winters, and sometimes, snow in the mountains. Sites close to the desert undergo large temperature differences between very hot days and cold nights.

Much of the deterioration caused by environmental factors is linked to the presence of water, which may derive from:

- Atmospheric precipitations: rain, snow, etc. ;
- Condensation: water vapor present in humid air is transformed into liquid water when it comes in contact with a surface colder than the air, such as the surface of a mosaic (Figure 13);

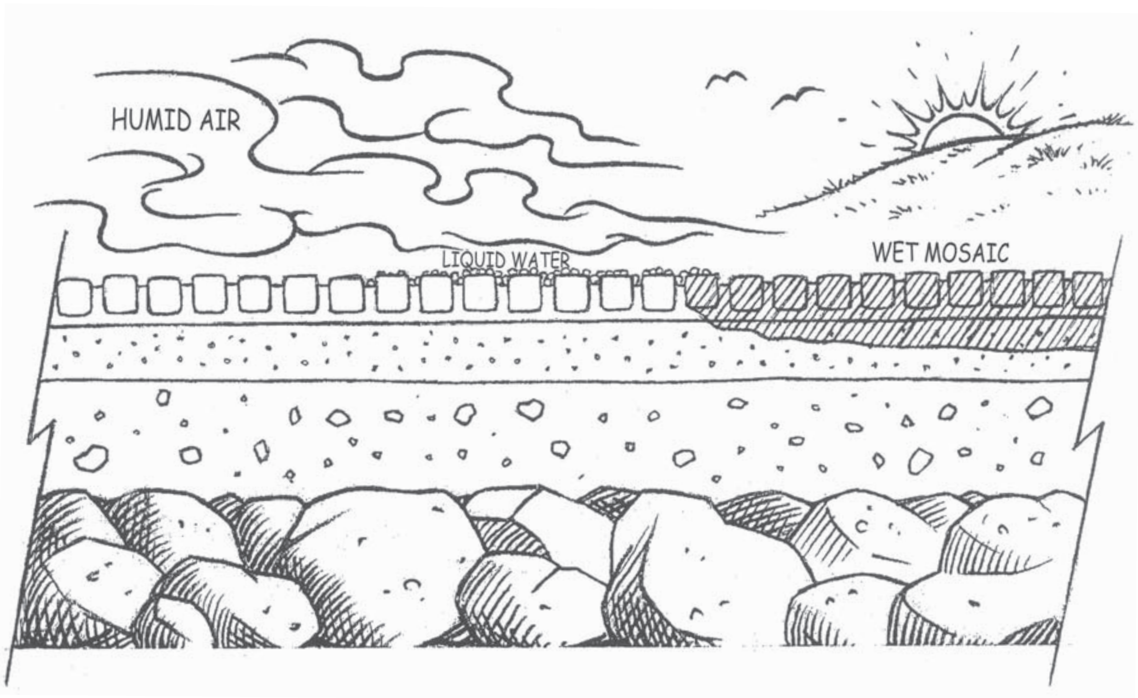

FIGURE 13 Condensation, when the surface is cooler than the air

- Capillary rise: water in the soil rises to the surface of a mosaic where it evaporates in the drier air. This water can come from the rain that saturates the soil or from a water table close to the soil surface. This water movement occurs continuously, but when a mosaic is exposed to air after being excavated, the water that evaporated at the ground level, above the mosaic, now evaporates at the mosaic surface, which is much more damaging for the mosaic (Figure 14).

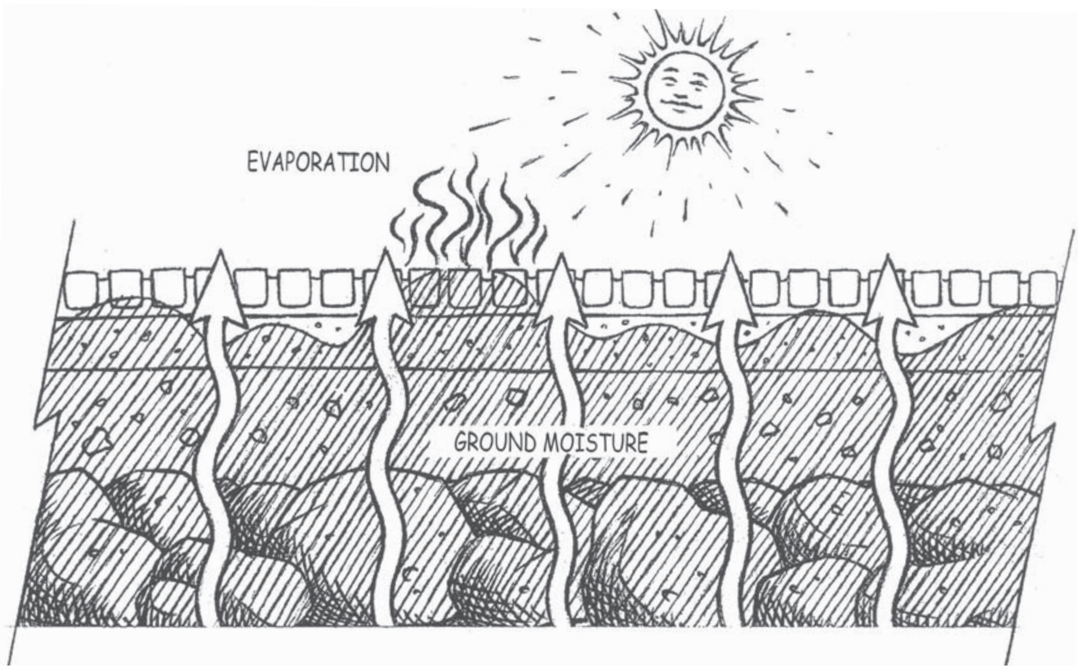

FIGURE 14 Capillary rise of water

Environmental conditions can affect the materials of the mosaic by triggering various deterioration mechanisms (Table 2). Most of the time, damage happens gradually through recurring aggressive action of the environment. Below are a few simple explanations of how certain deterioration mechanisms related to the presence of water can occur.

Salt crystallization due to wet-dry cycles

Ambient humidity diminishes when the temperature rises, causing water contained in the mosaic to evaporate. If the water contains dissolved salts, these will be transformed into crystals during evaporation. If the salts crystallize within the mosaic, they fracture the materials containing them. If they crystallize on the surface of the mosaic, they form efflorescences, generally white powder-like or whisker-like crystals, loosely adhering to the mosaic surface. After a long period of time, salts can also form incrustations or mineral crusts that are often hard and compact which can strongly adhere to the mosaic surface (Figure 15).

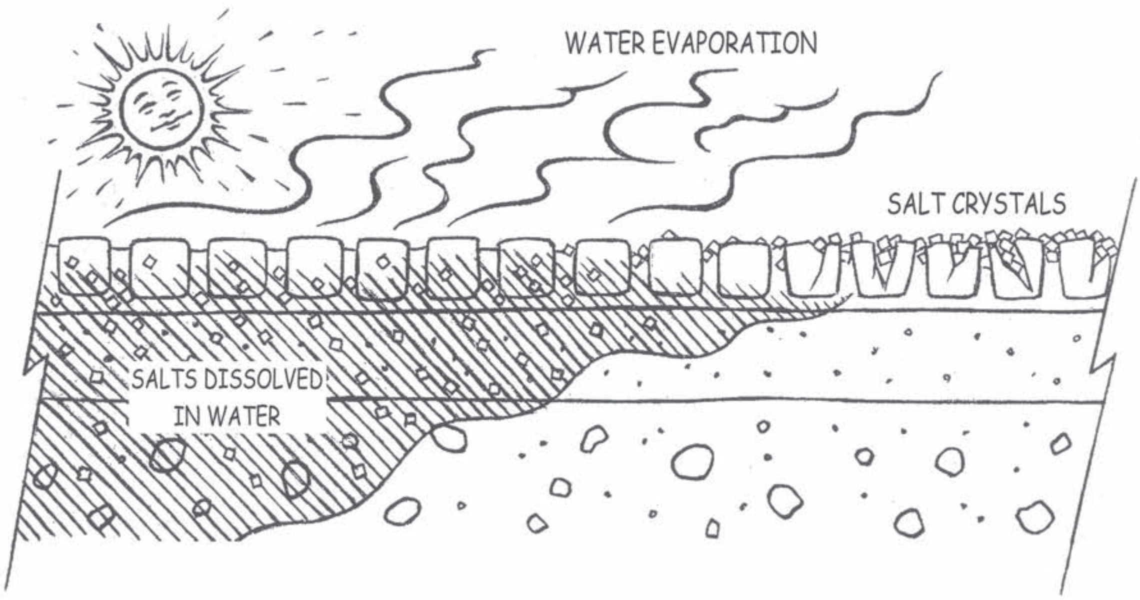

FIGURE 15 Salt crystallization

Contraction-dilatation cycles

Mosaic materials can increase in volume if they absorb water or if there is a steep temperature rise. This increase in volume, or dilatation, generates the compression of the materials within the mosaic, causing cracks and detachment of its uppermost layers.

Freeze-thaw cycles

When the ambient temperature falls below 0° C, the water contained in the mosaic materials turns into ice, causing them to fracture.

Bio-deterioration agents

The impact of animals and plants is also a significant cause of mosaic deterioration (Figure 16). Climate influences the type of animals and plants found at a given site and the severity of damage they can cause. Certain animals and plants will cause far more severe damage than others (Table 2).

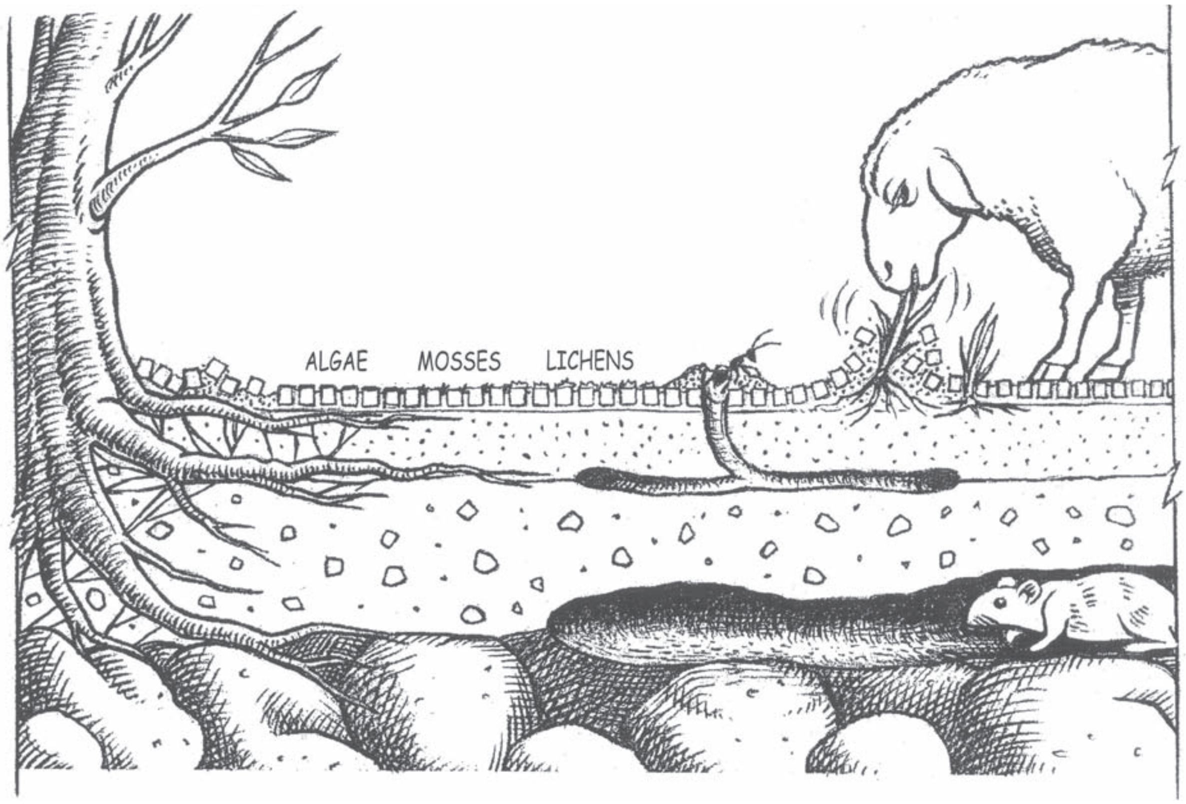

FIGURE 16 Deterioration caused by animals and plants

Table 2 Mechanisms of Deterioration

Factors	Causes & Examples		Examples of Mechanisms	Main Phenomena
Environment	Climatic phenomena	Temperature and humidity variations Marine humidity and salt Winter snow Temperature below 0°C	Salt crystallization due to wet-dry cycles of mosaic materials	Efflorescence / Incrustations Deteriorated tesserae
			Contraction–dilatation cycles of the mosaic materials	Bulges / Detachments Lacunae / cracks
			Freeze-thaw cycles of mosaic materials	Deteriorated tesserae Deteriorated mortar between tesserae
	Bio-deterioration agents	Micro-organisms (algae, lichens, moss, etc.)	Chemical transformation of mosaic materials Root growth	Deteriorated tesserae Deteriorated mortar between tesserae
		Vegetation (grass, plants, bushes, trees, etc.)	Root growth	Bulges / Detachments Lacunae / Cracks Detached tesserae / Stains
		Animals (insects, rats, moles, sheep, cows, etc.)	Digging of tunnels & building of nests Walking on mosaics	Bulges / Depressions Detachments / Lacunae / Fractures Detached and deteriorated tesserae / Stains
	Natural disasters	Earthquakes Flooding Fire	Ground movements Ground settling/subsidence Contraction–dilatation cycles	Lacunae / Cracks Bulges / Depressions Detachments / Detached tesserae
	Pollution (chemical substances present in air, water and soil)	Agricultural fertilizers Car exhaust emissions Industrial discharges into water and air Acid rains	Chemical transformation of mosaic materials Salt crystallization	Deteriorated tesserae Deteriorated mortar between tesserae Stains Efflorescence / Incrustations
Human activities	Poor management of archaeological sites	Lack of a conservation program during and after excavations Lack of maintenance Lack of visitor management	Water pooling Walking on mosaics Growth of vegetation and micro-organisms	Lacunae / Cracks Detachments Bulges / Depressions Detached tesserae Deteriorated tesserae Deteriorated repair mortars Deteriorated support panels Stains
	Inappropriate conservation interventions	Poorly executed work Use of inappropriate materials Untrained staff	Chemical, physical and mechanical stress	
	Gratuitous, deliberate or accidental destruction	Vandalism, wars, etc. Theft of mosaic fragments Illegal excavations	Mechanical stress	
	Poor land use planning	New constructions (buildings, roads, etc.) without proper excavation	Mechanical stress	

Micro-organisms

Micro-organisms are small living organisms which can be of different colors and shapes. Those most commonly found adhering to mosaic surfaces are algae, lichens, and mosses.

Algae are generally green or black. Algae can grow on the surface of the mosaic and under the tesserae, and even inside the tesserae and the mortars.

Lichens take root directly on the tesserae surface. They form a layer which can be of different colors and which can, in certain cases, entirely cover a mosaic surface.

Mosses, which are small plants, take root in damp areas where soil is present, for example in the interstices between mosaic tesserae.

These various micro-organisms often cohabit and their presence contributes to keeping the mosaic damp, thereby causing the deterioration of its materials and promoting the growth of larger plants.

Vegetation

Grass and plants grow in soil present in the interstices between tesserae, cracks and lacunae of a mosaic, as well as in the interstices between tesserae. Trees, shrubs and bushes grow in the soil around the mosaic. Plant roots can grow under the mosaic or within it, in between its layers, even if it does not contain soil. They can then crack the layers and also cause their detachment.

Animals

Animals, like large plants, can also provoke structural deteriorations. Ants and other insects build their nests; rats, moles and other small animals dig tunnels within or under the mosaic.

Sheep, cows and other large animals deteriorate the mosaic by walking on it and by pulling out plants that are rooted in or close to the mosaic.

Natural Disasters

Exceptional events such as earthquakes or violent floods can also cause the sudden deterioration and loss of mosaics (Table 2).

Pollution

Air and water pollution is also an environmental factor affecting the deterioration of mosaics (Table 2).

Some chemicals from factories or agricultural fertilizers are dissolved in rainwater and soil moisture. These substances may cause deterioration if in contact with the mosaic. In particular, polluting substances can deteriorate or chemically alter calcareous materials (lime mortars, limestone, and marble).

HUMAN ACTIVITIES

Human activities are also a significant cause of mosaic deterioration (Table 2). Among these activities are:

- *Poor management of archaeological sites:* lack of a conservation and maintenance program, poor planning of conservation interventions and documentation during excavations, abandonment of mosaics after their excavation, and poor management of visitors, leading to mosaics being walked on by tourists.
- *Inappropriate interventions:* poorly executed work and use of potentially damaging materials such as cement, plaster, iron elements and irreversible resins.
- *Destruction*, gratuitous, deliberate, or accidental, due to vandalism, wars, or the removal of a few souvenir fragments, etc.
- *Theft* of mosaic sections for the purpose of selling them.
- *New constructions* (houses, roads, etc.) leading to destruction of part of a site and its mosaics.

INHERENT PROPERTIES OF THE MATERIALS

Besides the environment and human activities, mosaic deterioration depends on the inherent properties of the materials of a mosaic. Each material has unique characteristics such as hardness, mineral composition, etc. In particular, all mosaic materials (stone, mortar, ceramic) are porous, but the amount of water they can absorb depends on the quantity and the structure of their pores. Thus, two different materials exposed to the same environment will not deteriorate in the same way.

For example, within the same mosaic pavement, it can often be observed that tesserae of a certain stone type are much more deteriorated than others. Similarly, mortars can be more or less resistant. Within the same building, some mosaics can be made with well-made mortars which are still in good condition, while other mortars are much more deteriorated.

Although the possible causes of in situ mosaic deterioration are numerous, some of which are described above, it is important to identify which ones have the greatest impact on a given mosaic. With this approach, it should be possible, with the site manager's agreement, to take measures to eliminate these causes to the greatest extent possible, thus avoiding future deterioration, rather than carrying out periodic repairs on a mosaic that continues to deteriorate. Because of the frequent inspections they perform, maintenance technicians are perhaps in the best position to identify the primary causes of deterioration, and then develop a protection and stabilization program with the help of others.

CHAPTER 5

INTERVENTIONS

LEVELS OF CONSERVATION TREATMENT

Conservation treatments can be divided in three categories according to the aims pursued and the degree of intervention.

First-aid or emergency care

The purpose of first-aid treatments is only to stabilize the areas of the mosaic in danger of immediate loss, pending intervention within the framework of a full treatment program. They generally include operations to temporarily protect the edges of the mosaic as well as localized stabilization work.

They are generally carried out over a short period of time, when the mosaic is exposed for the first time during excavation or during construction work, or when an excavated mosaic has suffered sudden damage or prolonged neglect.

Emergency treatments should be documented but the documentation can be carried out quickly.

Conservation

The purpose of conservation treatments is to restore both the structural and the aesthetic integrity of the whole mosaic. They generally include the following operations:

- cleaning of the surface,
- stabilization of the tesserae and mortar layers,
- consolidation of the materials of the mosaic (stone, brick, mortar, etc.),
- operations of aesthetic presentation.

Conservation treatments should be based on preliminary investigations conducted to obtain a comprehensive condition assessment of the mosaic, and on analyses to try to identify the causes of the deterioration of the mosaic. Investigations and analyses enable a conservator to establish a methodology (the types and sequence of operations to be carried out and the materials to be used) as well as a conservation program (duration and cost of labor). Conservation programs must include a maintenance program for the mosaic over the long term after this first intervention.

The whole conservation process should be accurately documented in detail.

In the past, conservation treatments often consisted in lifting mosaics and transferring them onto a new support. However, these operations should only be carried out in exceptional cases where the mosaic would be immediately lost if it were not lifted and transferred. Currently, it is considered much more appropriate to leave mosaics in situ in their architectural context.

Maintenance

The purpose of maintenance interventions is to preserve the structural integrity of the mosaic over a long period of time after its conservation treatment or initial stabilization intervention carried out by technicians (page 101).

These interventions are planned when necessary on the basis of regular inspections to check the condition of the mosaic and of the previous interventions.

They include:

- Operations to prevent the progression of mosaic deterioration by controlling its causes, for example, regular weeding of the mosaic surface, elimination of accumulated water, sand and soil, and improvement of drainage in the room containing the mosaic.
- Cleaning and localized stabilization of the mosaic in areas where new deterioration has appeared since the last maintenance campaign.
- Replacement of modern repair mortars that are no longer effective or are damaged.
- Reburial maintenance (page 108), repairs of protective shelters and other interventions carried out around the mosaic.

These three categories, first-aid, maintenance, and conservation, represent the different possible levels of mosaic treatment, from the minimum to the most complete. Every mosaic can be the subject of each of these different treatment levels at different moments depending on its condition, its exposure and the resources available for its conservation. However, regular maintenance should normally offset the need for first-aid treatments.

The main work of a technician is to carry out mosaic maintenance but s/he can also carry out some simple first-aid operations and contribute to the conservation of mosaics under the supervision of a conservator.

In some cases, when an excavated mosaic has been abandoned for years, and therefore its condition is generally poor, a technician must first plan and carry out stabilization work that can take a long period of time, before s/he can begin to carry our regular maintenance on the mosaic. The operation of general stabilization of a mosaic in poor condition is called "initial intervention". It must be followed by maintenance cycles which consist of regular inspections of a mosaic already stable and in good condition, accompanied, if necessary, by localized and relatively minor stabilization interventions.

CLEANING

A periodic maintenance program for in situ mosaics includes cleaning operations. Within the framework of maintenance activities, the purpose of cleaning operations is:

- to remove substances and materials from the surface of the mosaic that could be responsible for its deterioration;
- to enable a better assessment of the mosaic's condition by making its surface more visible;
- to prepare the mosaic for mortar-based stabilization treatments.

Before beginning to clean, it should be ensured that cleaning is compatible with the mosaic's condition; an overly forceful action on a fragile mosaic can lead to the detachment of tesserae. If the mosaic is very damaged, stabilization may be necessary to reinforce the mosaic before cleaning it.

In the course of the cleaning during mosaic maintenance, anything that could potentially undermine the conservation of the mosaic should be removed. For an in situ mosaic, vegetation growing on or around the mosaic, soil and other debris deposited on its surface and particularly in between the tesserae, as well as micro-organisms adhering to it should be removed. Finally, modern repair mortars, if they are damaged or are damaging the mosaic, should be removed.

The removal of soil, especially when it is found under the tesserae, is a particularly important operation to ensure that lime-based treatment mortars adhere to the original materials.

Cleaning should be carried out gradually, starting with the removal of less strongly adhering deposits, like soil, before proceeding to more strongly adhering deposits, such as micro-organisms (lichens, etc.). Chemicals should not be used for cleaning as they can damage mosaics.

Cleaning can be carried out with or without water (Figures 17 and 18). During cleaning, water should be used in minimal amounts and changed as soon as it becomes dirty.

The most commonly used cleaning tools are scalpels, dental tools, wooden sticks, chisels, various kinds of brushes (never metal brushes), paintbrushes, manual blower bulbs, vacuum cleaners, sponges and hand-held water sprayers. Each tool has specific characteristics and must therefore be used for specific operations. The incorrect use of a tool can damage the mosaic and break the tool.

Cleaning operations carried out only for aesthetic purposes are considered beyond the scope of maintenance activities.

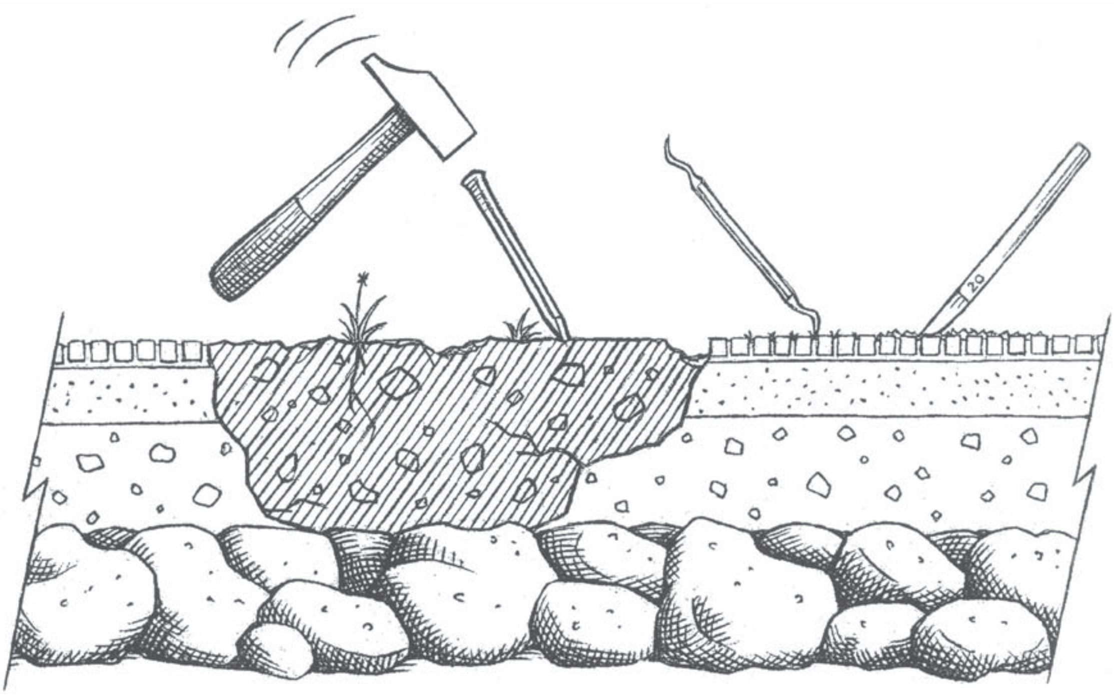

FIGURE 17 Cleaning without water

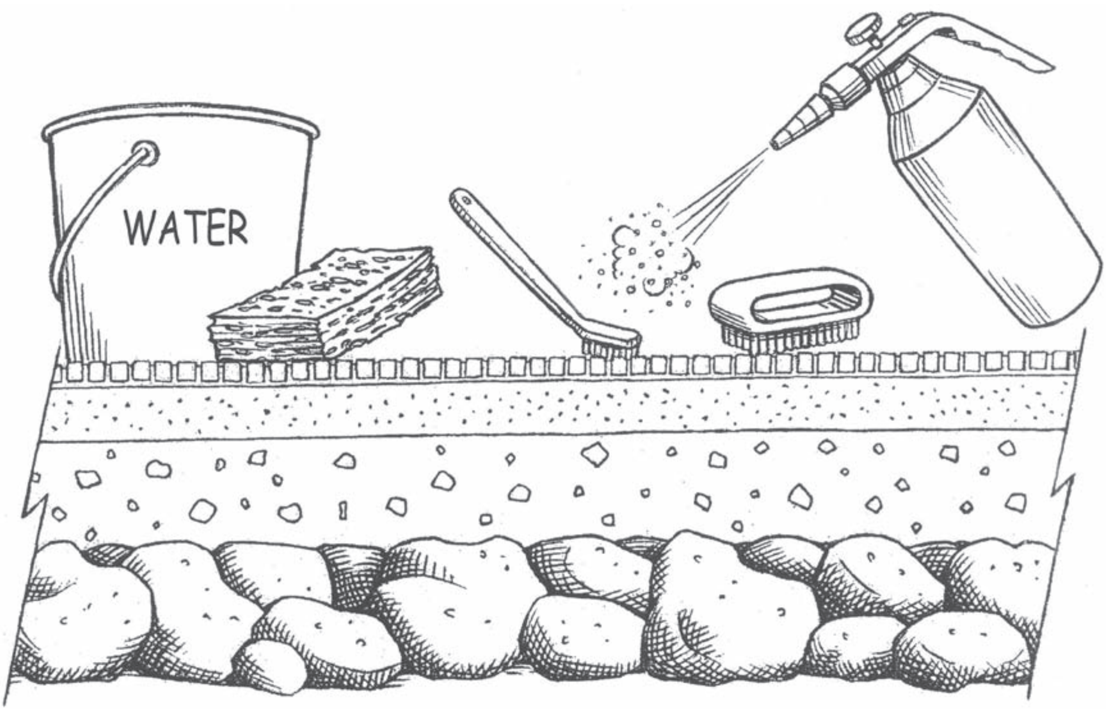

FIGURE 18 Cleaning with water

MORTARS

Mortars are used for all mosaic stabilization operations. A mortar is the combination of a binder (lime, etc.), aggregates (sand, gravel, etc.) and the appropriate quantity of water. This mixture is used while still soft and malleable, and fulfills its structural function when it sets and becomes hard.

Binders

A binder is a material that keeps aggregates together when the mortar is set and has become hard. Binders can be divided in two categories: non-hydraulic and hydraulic binders. A non-hydraulic binder needs to be in contact with air to set, whereas a hydraulic binder sets predominantly when in contact with water.

Non-hydraulic binders

Lime putty (non-hydraulic lime putty)

Making lime putty starts with burning pure limestone. Limestone is transformed into quicklime by combustion. Quicklime is then transformed into lime putty when water is added. This latter operation is called the slaking of quicklime. Lime putty, which is generally white and thick, is obtained by slaking quicklime with excess water. Lime putty keeps for a very long time (years) and its properties improve with age if kept under water. When lime putty is exposed to air, it hardens and is transformed into a material that has the same composition as the original limestone (Figure 19).

Hydrated lime (non-hydraulic powdered lime)

Hydrated lime is made the same way as lime putty, i.e. by burning pure limestone. The difference is that only the minimum quantity of water is added to the quicklime to thoroughly transform it without leaving any excess water. This produces slaked lime in the form of a white powder rather than as putty. Like lime putty, hydrated lime sets in contact with air; it is therefore also non-hydraulic lime (Figure 19).

As a powder, hydrated lime must be stored in a dry place. It can be turned into lime putty by adding water. It can then be kept under water for a very long time.

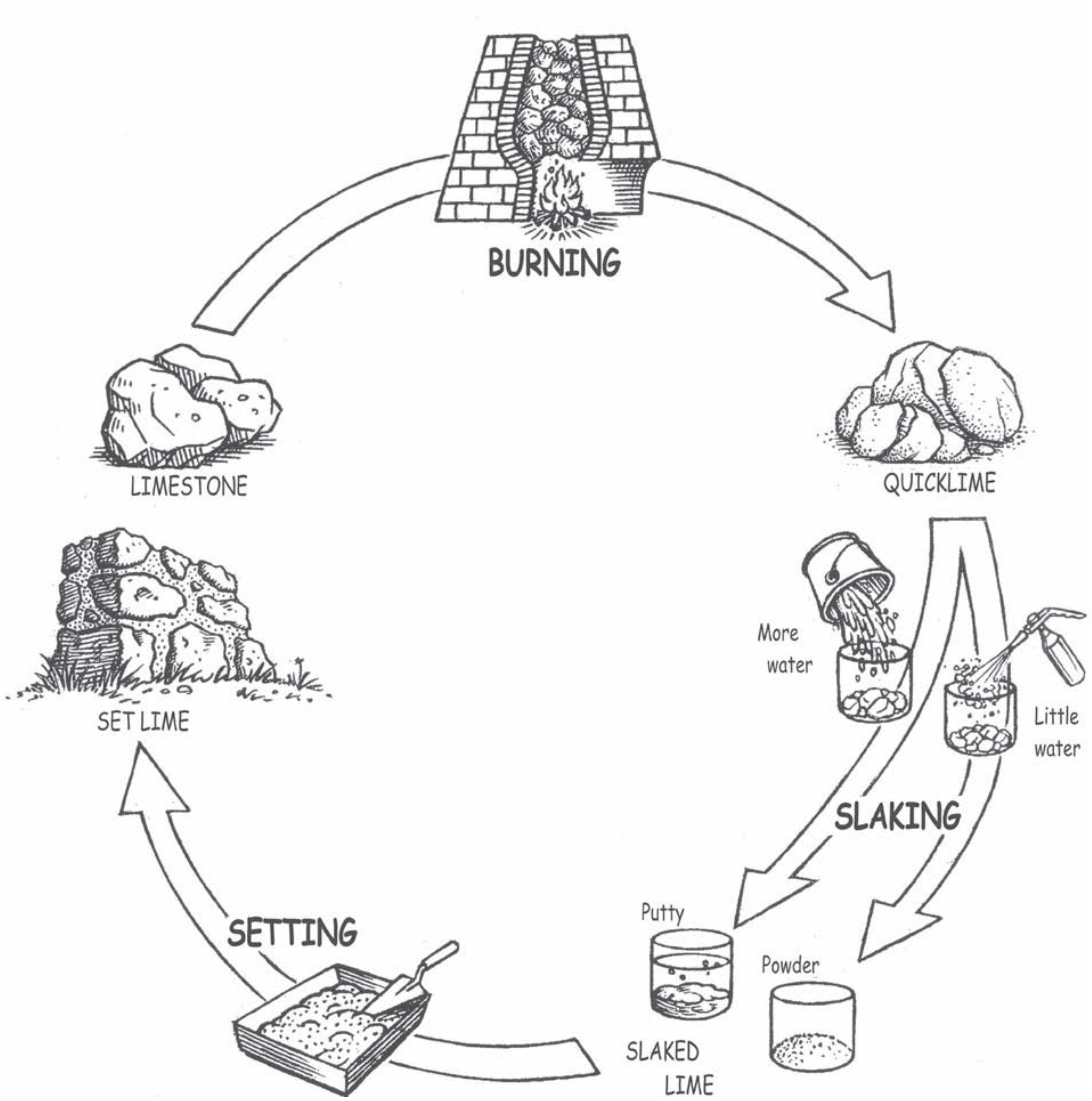

FIGURE 19 Lime cycle

Hydraulic binders

Natural hydraulic lime (powder)

Natural hydraulic lime, often abbreviated as NHL, comes from impure limestone containing other minerals (silica, alumina, etc.) and has the capacity to partially set in the presence of water and partially in contact with air. The manufacturing process of hydraulic lime is similar to that of non-hydraulic lime, except that the limestone is burned at a higher temperature. Lime gets its hydraulic properties of setting in contact with water from the presence of these impurities that are burned at high temperature. Hydraulic lime can be slightly or strongly hydraulic depending on the type of limestone used and the burning temperature.

Natural hydraulic lime should be stored in a dry place and be used quickly after its manufacturing date.

Artificial hydraulic limes and cements (powder)

To make these materials, additional products are added to the stone during the manufacturing process. The additives give these materials significant hydraulic properties contributing to their great hardness. Due to their manufacturing process, these materials also contain soluble salts.

Artificial hydraulic limes and cements should be stored in a dry place.

For all conservation and maintenance work on in situ mosaics, **it is strongly advised to use natural lime-based mortars** (lime putty and natural hydraulic lime) because their chemical composition and their physical characteristics are similar to those of ancient materials. Artificial hydraulic limes and cements are generally too hard and also contain soluble salts that can deteriorate mosaics. For the maintenance of mosaics which have been lifted and re-laid on a reinforced concrete support, white cement-based mortars are sometimes used (page 119).

Aggregates

Aggregates make up the skeleton of the mortar: their hardness contributes to its strength and they help decrease mortar shrinkage during setting. A good aggregate should be clean, that is, should not contain soil, dust, and especially salts. The cleanliness of an aggregate can always be improved by washing it with water.

Aggregates can be divided in two main categories: those that are inert and those that react with the binder to give hydraulic properties to the mortar.

Inert aggregates

Sand and gravel

Sands and gravels are inert aggregates because they do not react chemically with binders.

Sands can come from a riverbed or a quarry. They have small-size grains. Sands from quarries are generally less clean than river sands which have been naturally washed. Beach sands should not be used because they contain a lot of salt.

Gravels come from quarries and are crushed pieces of stone. There are many types of sands and gravels of different sizes with different hardness, color and particle shape.

Aggregates giving hydraulic properties to a mortar

Fired clay, volcanic earths and rocks

Bricks, tiles or pottery made of fired clay, crushed and ground, can be used as aggregates and can give hydraulic properties to lime putty mortars. The reactivity of these materials with lime depends on the type of original clay and on its firing temperature. It is generally considered that if the clay firing temperature is very high, the material reactivity will be less significant or even non-existent; this is the case for a lot of modern bricks.

Some volcanic earths and rocks, such as pozzolana, are naturally able to chemically react with lime in the presence of water and can give a mortar a strong hydraulic set.

Factors influencing the properties of a lime-based mortar

Choosing the type and quality of each of the mortar ingredients (binder, aggregates and water) and their respective proportions will determine the characteristics and performance of the mortar during its preparation, application and when it has set.

Non-hydraulic and hydraulic properties

Depending on the type of binder and aggregates mixed together, a mortar can be non-hydraulic, i.e. it needs to be in contact with air to set, or hydraulic, i.e. it sets in contact with water.

A non-hydraulic lime-based mortar is obtained by mixing non-hydraulic lime and inert aggregates.

There are several ways of obtaining a hydraulic lime-based mortar. It can be a mixture of non-hydraulic lime and aggregates giving hydraulic properties to a mortar, or a mixture of natural hydraulic lime and inert aggregates or aggregates giving hydraulic properties to a mortar. The degree of hydraulicity of the mortar varies depending on the types of lime and aggregates used.

In general, hydraulic mortars are harder than non-hydraulic ones and they can set even if they only have limited contact with air.

Binder-aggregate ratio

The ratio of binder to aggregates strongly influences the properties and performance of a mortar. Most of the time, one part (in volume) of binder is mixed with two to three parts of aggregates, that is, a binder-to-aggregate ratio between 1:2 and 1:3 in volume.

A mortar containing more lime (a lime-rich mortar) is easier to use, more malleable, and adheres more easily, but it will tend to have larger shrinkage and will therefore crack more easily while setting. This is especially true for lime putty mortars. Once set, a lime-rich mortar is also softer than a mortar containing more aggregate.

A mortar containing less lime (a lime-poor mortar) is less malleable and adheres less easily, but it will tend to shrink less. Once set, a lime-poor mortar is more friable than a mortar that contains less aggregate.

Mortar shrinkage is due to the mortar decreasing in volume when it loses water.

Particle -size distribution of aggregates

The particle-size distribution of aggregates also influences the properties and performance of a mortar. To make a good mortar, aggregates should have a good particle size distribution between coarse and fine particles.

If all the particles in a mortar are the same size, they will form unequal voids (poor compaction) and there will be a greater build-up of binder in some areas than in others. If the particles are of different sizes, they will distribute themselves so as to fill all the voids (good compaction) and the thickness of the binder distributed around the particles will be constant. A more even distribution of the binder makes the mortar stronger (Figure 20).

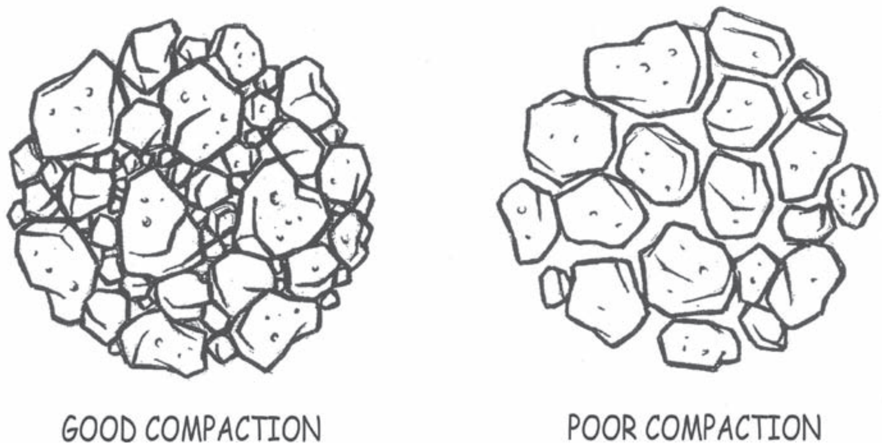

FIGURE 20 Distribution of aggregate particles

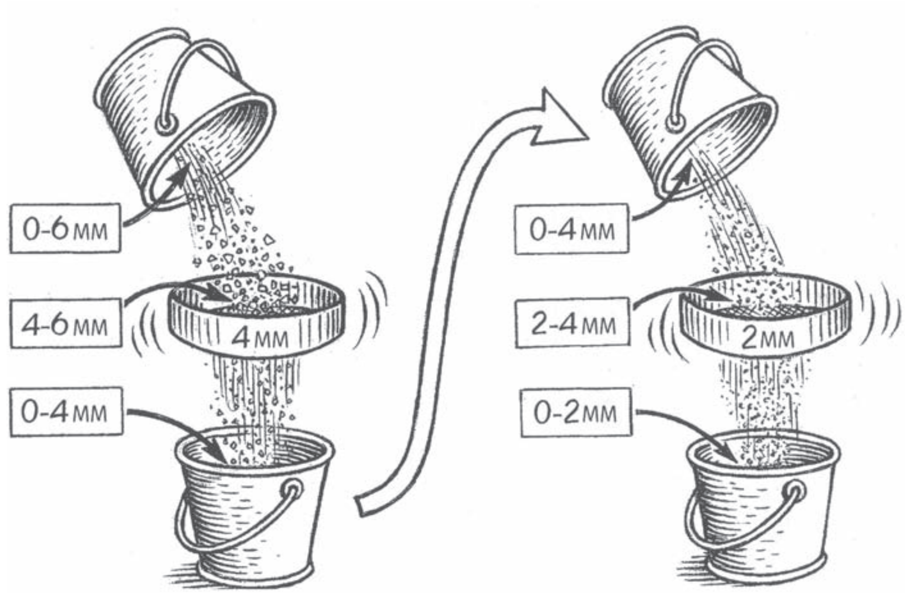

FIGURE 21 Sieving of aggregates in several fractions

Furthermore, aggregate size is chosen according to the required thickness of the mortar. The thicker the mortar needs to be, the larger the aggregates should be.

To obtain a mortar with a good particle size range, different kinds of sands, gravels, and stone powders can be used and sieved to obtain fractions of different sizes that are mixed in the proper proportions (Figure 21).

Proportion of water in a mortar

The amount of water used to prepare a mortar, called the mixing water, is a factor that influences the properties and performance of a mortar. Using a lot of mixing water makes the mortar more malleable, but will cause significant shrinkage when the water evaporates, causing the mortar to crack. Using too little water makes the mortar harder to work and it will adhere poorly. In addition, this will result in a poor setting of hydraulic as well as non-hydraulic limes.

Non-hydraulic and hydraulic mortars must be kept moist throughout the setting period to insure that the whole mass of mortar sets completely.

Liquid mortars, also called grouts, are a particular type of mortar containing a larger amount of water compared to paste mortars. The correct amount of water to use should be the smallest amount necessary to make the mortar fluid, yet be injectable. In any case, the amount should not be more than one part of water to one part of binder.

It is important to use clean water to mix mortar and to it ensure it does not contain salts.

Color and texture

The visual appearance of a mortar, due in particular to its color and its surface texture, is a result of the selection of the binder and aggregates and of their ratios. The binder influences the mortar color through its own color. The aggregates influence both the mortar color and surface texture through the color, shape and size of their particles. For the aggregate particles to contribute to the color of the mortar, it is necessary to make them visible by removing a thin layer of binder from the mortar surface with a wet sponge before it sets.

Mortars for mosaics stabilization interventions

The quality of any mortar depends of its own characteristics. It is especially important that a mortar used to stabilize ancient mosaics, as with any good-quality mortar, should not contain soluble salts and that, once set, cracking should be limited, i.e. it should be stable and durable over time.

A mortar used for the stabilization of ancient mosaics should also have additional characteristics:

- It should have a **good affinity** with the ancient materials and, in particular, its hardness and porosity should be similar and it should permit a similar movement of water in the ancient materials and in the mortar.
- A stabilization mortar should also be **reversible**, that is, it should be removable without deteriorating the mosaic.

This is why mortars made of non-hydraulic or naturally hydraulic lime should be used. Because a mortar made of cement or artificial hydraulic lime cannot fulfill the above conditions, it is strongly advised not to use them for the stabilization of ancient in situ mosaic.

In addition, a mortar used for mosaic stabilization should have a color and surface texture that do not stand out; rather, the mosaic surface should always stay visually dominant.

To choose the most appropriate intervention mortar for a given in situ mosaic, its construction technique, condition, exposure conditions, as well as, the climate of the archaeological site where it is located, should also be taken into consideration. Finally, a stabilization mortar should also have the properties required for the operation it will be used for (resetting tesserae, or protecting mosaic edges, etc.).

STABILIZATION

During maintenance work, interventions on in situ mosaics consist mainly in carrying out periodic and programmed stabilization operations using lime-based mortars. The aim of these interventions is to restore the structural stability of the mosaics and prevent any new deterioration from occurring.

The main types of interventions requiring mortars are:

- Resetting detached tesserae in their original position and orientation (Figure 22);

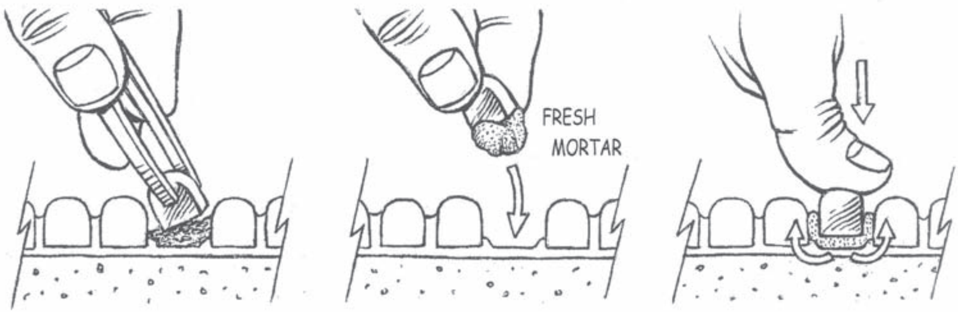

FIGURE 22 Resetting detached tesserae

- Filling interstices between tesserae (Figure 23);

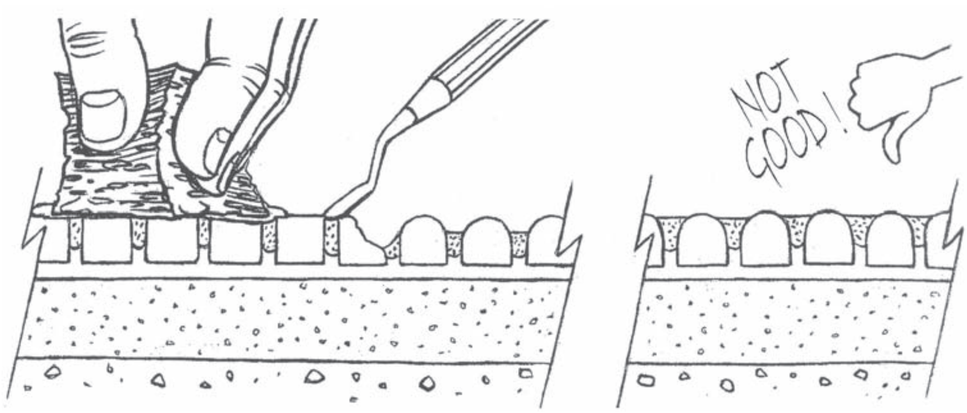

FIGURE 23 Filling interstices between tesserae

- Protecting tessellatum edges (Figure 24);
- Filling lacunae and cracks (Figure 24);

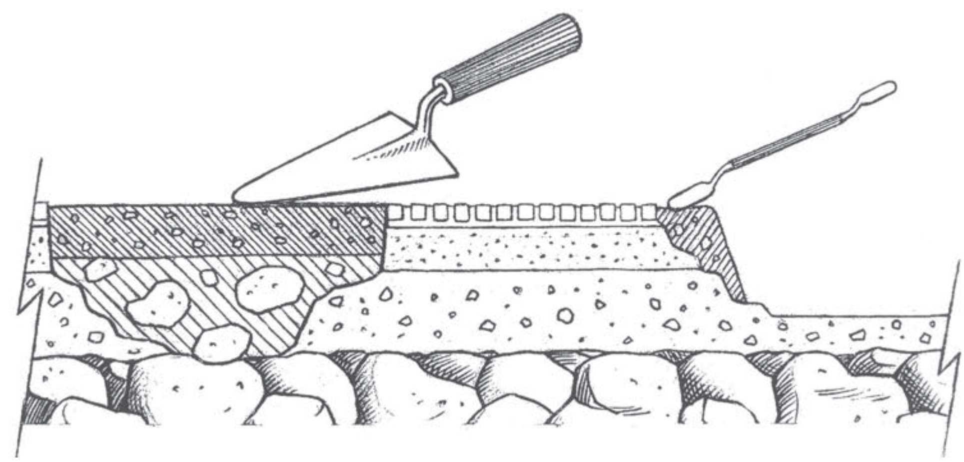

FIGURE 24 Filling lacunae and edging repairs

- Grouting voids located between the preparatory layers of the mosaic (Figure 25).

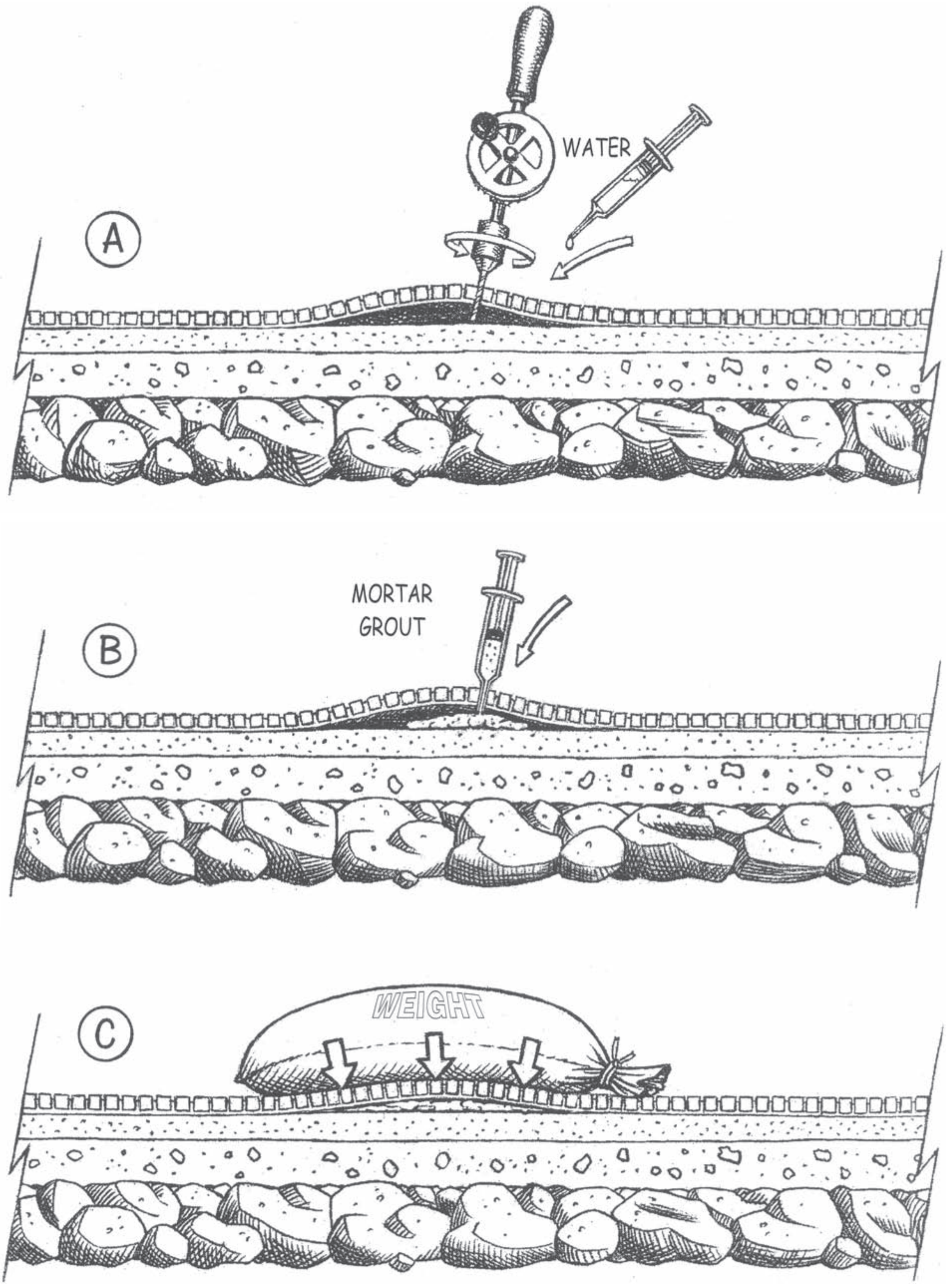

FIGURE 25 Grouting voids between preparatory layers

Cleaning must be carried out to remove dust, soil, and micro-organisms before any stabilization intervention, to ensure that stabilization mortars can adhere properly to the surfaces of preparatory layers and to the sides of the tesserae.

If the surfaces of preparatory layers inside lacunae are fragile, they can be consolidated with lime water before undertaking stabilization operations.

Each stabilization intervention requires a specific mortar with particular characteristics. Depending on the intended use, a mortar may require a specific hardness and workability and, if the mortar is to be visible, a specific color and texture.

For example, to reset detached tesserae, the use of a lime-rich mortar made of lime putty and a fine aggregate is recommended. Lime putty is chosen as a binder because the mortar should have good adhesive properties and be malleable – two characteristics of lime putty that are accentuated by the fact that the mortar contains a lot of binder. A fine aggregate should be used so that the mortar does not create an additional thickness under the tessera being reset and that it fills the narrow spaces around each tessera.

A liquid mortar (also called grout) containing very fine aggregates should be used to fill a void between the mosaic preparatory layers, by injection using a syringe. Hydraulic lime should be used as a binder because the mortar must be able to set despite a very limited contact with air.

To fill a very deep lacuna, either a hydraulic mortar applied in one layer, or a non-hydraulic mortar applied in several layers, can be used. The thicker the mortar layer needs to be, the larger the aggregates should be to improve strength and to diminish shrinkage and cracking of the mortar.

To make a surface fill of a lacuna that will be exposed to the weather and walked on, a hydraulic mortar should be used because it is harder and more resistant. As with any surface mortar that will remain visible, aggregates of the appropriate color and size should be chosen carefully because attention should not be drawn to the intervention mortars when looking at the mosaic. The color and texture of the mortar should therefore blend in visually with those of the mosaic so that the mosaic surface always remains visually dominant.

To achieve less evident repairs, during Antiquity and in the last century, lacunae were sometimes filled with ancient tesserae set in a new bedding mortar. Today, it is considered more appropriate to emphasize the original pavement by making it easier to recognize the original areas of the mosaic from the areas where materials have been recently added to stabilize it and fill in missing parts. The reintegration of a lacuna with tesserae is therefore a stabilization intervention which is strongly discouraged.

To choose the composition of mortars needed for stabilization, it is useful to gather a range of binders and aggregates and to prepare a number of mortar samples. They can then be evaluated in the field and, if it is also possible, in the laboratory with the help of a conservator. It is preferable to make samples of each mortar one intends to use. When the mortars are chosen, their composition (mortar formula) should be written down specifying for which kind of interventions they will be used.

For certain conservation problems, a conservator should be called upon. For example, if the preparatory layers of a mosaic or its individual tesserae are too fragile to be stabilized using only lime-based treatments, a conservator can consolidate the deteriorated constituent materials with other types of products. If large tree roots threaten a mosaic, a conservator may select an appropriate chemical (herbicide, etc.) and supervise its application.

During stabilization operations, it may be required to temporarily lift up a small section of the tessellatum, in order, for example, to remove roots or soil underneath. This operation may be necessary so that stabilization mortars adhere well to the preparatory layers' surfaces and to the sides of tesserae. To be able to lift a section of the tessellatum and avoid having to disassemble the tesserae one by one, facing can be used, that is, gluing a piece of fabric to the mosaic surface. Facing a section of the tessellatum with an adhesive to temporarily lift up together some of the tesserae is considered a specialized conservation treatment operation and should be supervised by a conservator.

The tools most commonly used for stabilization interventions are: spatulas, tweezers, small rubber bowls for small-scale operations, trowels, mortar buckets for larger-scale operations, hand

drills, syringes and needles for grouting with liquid mortar. Sieves of different sizes are used to prepare the aggregates. Water buckets, sponges and hand-held water sprayers are used to give a good finish to the mortars, while wet floor cloths and plastic sheets ensure that the mortars dry slowly.

A list of materials needed for an intervention campaign is provided in Appendix B (page 125).

HEALTH AND SAFETY MEASURES REGARDING LIME

Lime is not a toxic product; however, its prolonged use without protection can be hazardous.

Hand protection

Lime in its different forms as putty, powder, in a mortar or dissolved in water dries the skin. Extended skin exposure to lime can cause skin lesions that can become deep. It is therefore necessary to protect one's hands by wearing rubber gloves during all operations using lime.

Respiratory tract protection

Airborne dust blowing around during the handling and sieving of lime-based powder materials is harmful to the lungs. It causes respiratory tract irritations and, over a long period of time, accumulates in the body which can only eliminate a small fraction of it. It is therefore necessary to wear a paper dust mask during all these operations.

Eye protection

If lime gets in contact with the eyes, it causes strong burning. The eyes should be thoroughly rinsed with clear water immediately and at length (at least a quarter of an hour). In case of a prolonged irritation, one should see a doctor. It is therefore necessary to wear protective goggles during the operations when there may be projections of lime.

Safety measures to be taken when slaking quicklime

Mixing water and quicklime during slaking causes a chemical reaction that produces heat, bringing the water quickly to a boil. The reaction can be more or less violent depending on the quality and purity of the quicklime, its past exposure to humidity and whether it is in the form of stones or powder.

Great care must be taken when slaking quicklime and only small amounts of lime should be added to the water each time to limit the effects of the reaction and avoid splashing of boiling water or lime. This operation should be carried out in clean containers that are not sensitive to heat (plastic containers are generally not appropriate) and in an open area.

When slaking quicklime, gloves and protective goggles should be worn.

REBURIAL

Reburial is the temporary or permanent re-covering of archaeological remains exposed during the excavation of a site. It is done by using fill materials and separation layers, used alone or in various combinations and in different sequences (Figure 26).

Reburial is a protective measure designed to ensure the in situ conservation of mosaics. Its purpose is to slow down the deterioration of a mosaic by controlling some environmental factors to which an open-air mosaic is normally exposed. Like a shelter, the reburial of a mosaic will protect it against the direct action of the weather. In addition, it will provide a more stable environment around the mosaic. Finally, due to its thickness, it will protect the mosaic surface from mechanical deterioration caused by people walking on it, for example. Like any intervention, a reburial requires regular maintenance to remain effective.

A number of elements must be taken into consideration to ensure that the effects of reburial on the conservation of a mosaic are positive, and to minimize the potential negative effects. First of all, a condition assessment of the mosaic should be made, trying also to understand the causes of its deterioration. It is necessary to understand the properties of each material intended to be used, so that the reburial protects the mosaic from environmental conditions.

Fill materials such as soil or sand are used in more or less thin or thick layers to create a more stable environment, and to better protect the remains on the site. Separation layers, such as plastic netting, are thin layers used in sheets to avoid mixing the different fill materials, or to mark the boundary between these materials and the surfaces to be protected, and to thus avoid their contamination. Separation layers can also be used in the form of bags containing fill materials.

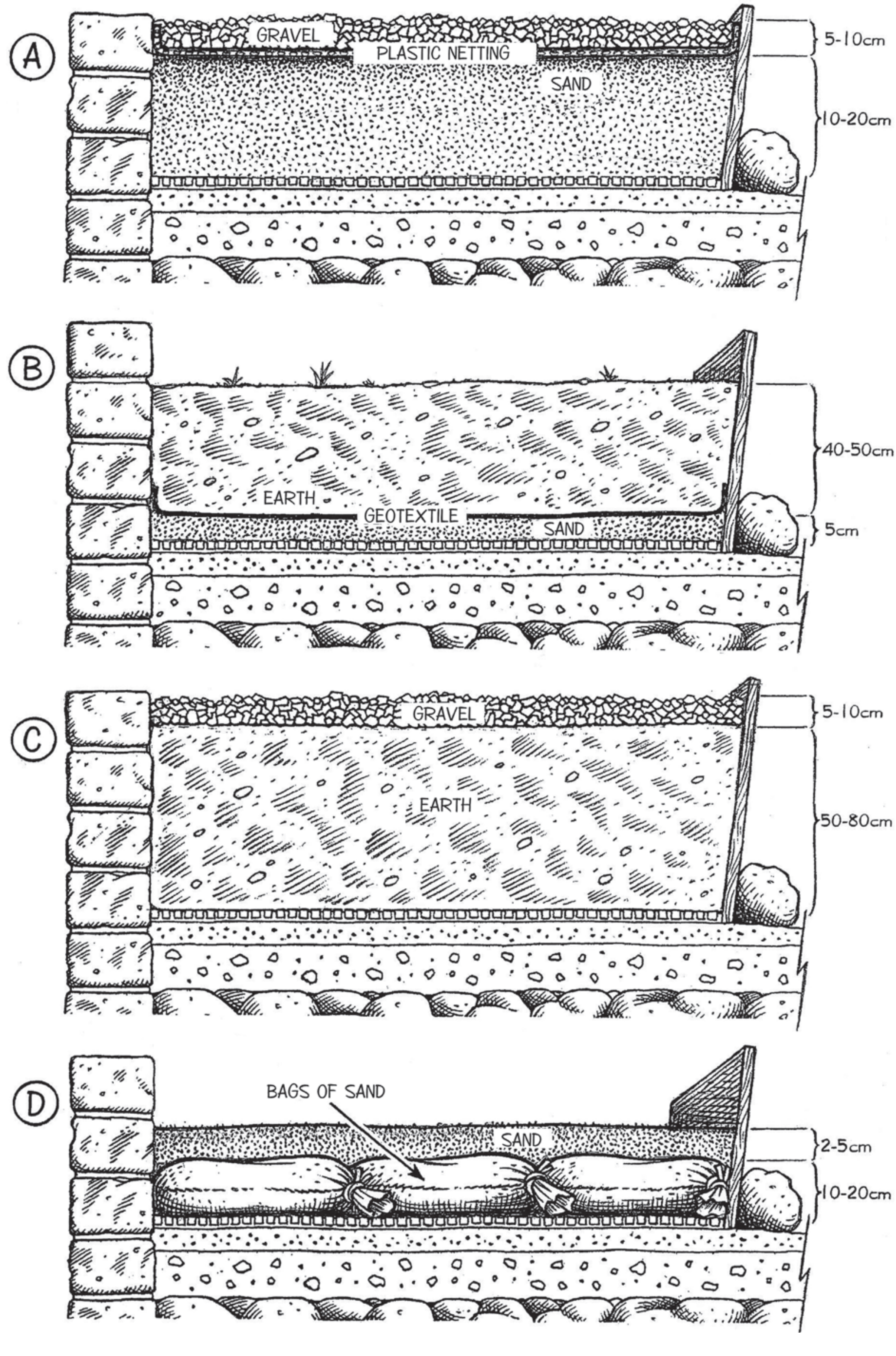

FIGURE 26 Examples of reburial

Important factors affecting the performance of a reburial

Water transport through the materials

It is important for water to circulate freely between the reburial and the mosaic. If liquid-water contained in the soil cannot pass easily from the mosaic to the fill materials above it (causing discontinuity in the capillary moisture rise), then water will evaporate at the mosaic surface. This will cause the crystallization of salts, if any are present, in this area, and eventually the deterioration of the mosaic.

Fill materials that do not allow liquid-water to pass through (impermeable materials) will trap moisture inside the mosaic, leading to the growth of micro-organisms and the development of roots.

It is also important that fill materials allow the mosaic to dry slowly when it is damp and to absorb water slowly when it is dry, that is, that they insure that the humidity within the mosaic changes slowly.

Temperature stability (thermal insulation)

Fill materials should insulate the mosaic as much as possible from temperature variations, especially, they should prevent it from freezing in the winter or becoming too hot in summer. Extremely low or high temperatures or very frequent changes in temperature cause deterioration of stone and mortar. The thicker a reburial fill layer is, the better insulation this layer will provide.

Vegetation growth and burrowing animals

Preferably, fill materials should impede vegetation growth. Therefore, materials should not retain moisture for long periods of time. They should not contain nutrients for plants or micro-organisms and must be difficult for roots to penetrate. Furthermore, materials should preferably impede insects or other animals from digging tunnels and holes and building nests.

Durability of materials over time

Preferably, fill materials should not deteriorate rapidly so that they do not damage the mosaic, and they continue to fulfill their function. For example, metallic netting buried just above the mosaic surface will rust and stain the mosaic. Many plastic materials will deteriorate quickly if exposed to the sun. Natural fibers, such as cotton, decompose in humid conditions and in the presence of micro-organisms.

Finally, it is important that all reburial materials remain in place on the mosaic, i.e., that they are not easily dispersed by rain, wind, etc. Effective and sustainable means should therefore be used to keep the reburial fills in place.

Practical considerations

Maintenance requirements

Reburials should be maintained regularly. Some materials require more time and work to be maintained in good condition. For example, soil allows plants to grow more easily and will require regular weeding. It is also easily eroded by rain and wind.

Accessibility

It is also important to consider the ease of moving and manipulating the materials. For temporary reburials in particular, it is preferable to work with materials that are easy to disassemble and remove from the mosaic surface without causing damage.

Separation of reburial layers

For a separation membrane to be an efficient divider, its mesh size should be smaller than the particle size of the fill material above it.

Availability and cost

The choice of materials is often limited by their cost and their local availability. For example, soil removed during excavation is sometimes used for mosaic reburial because it is readily available and at no cost. Its use is particularly easy if it is reused shortly after excavation, when the soil is still loose and devoid of vegetation.

Fill materials

Fill materials generally used for reburial are soil, sand, gravel or specialized materials (expanded clay pellets – Leca™, volcanic tuff pellets, beads or plates of expanded polystyrene, etc.). Each has its own advantages and disadvantages, and their use have positive and negative impacts on the mosaic (Table 3).

Soil

Soil is the material that is most similar to the one that preserved the mosaic for centuries until its excavation. There is a great variety of soils, each with their own properties. In general, soil provides good liquid-water/water-vapor transport. It also provides a good stability in temperature and humidity, if sufficiently thick. It is often readily available during or after excavation and, in this case, it does not cost anything. However, it generally contains seeds and little plants, and facilitates vegetation growth and animal activity. Consequently, it sometimes needs preliminary sieving and requires more frequent maintenance. It can also be eroded by rain and wind. Finally, soil will dirty the mosaic when in direct contact, which will require extensive cleaning, if the mosaic is later presented, especially if the mosaic is in poor condition.

Sand

Sand is generally less prone to vegetation growth and animal activity than soil. It therefore requires less maintenance. Sand is also cleaner, but may sometimes contain salts. It will require less cleaning after its removal, but its small grains can still be difficult to remove from the most damaged parts of a mosaic. Moreover, liquid-water/water-vapor transport and temperature stability are not ensured as effectively by sand as by soil for the same thickness. It can be eroded by rain.

Gravel

Gravel is the material that best prevents vegetation growth and animal activity due to the size of its particles. It is also easy to remove from the mosaic surface and is less eroded by rain than soil or sand. However, it is hard and has sharp edges and can be heavy. It does not provide good liquid-water transport and good temperature and moisture stability because of the spaces between particles.

Table 3 Fill Materials

Type	Advantages	Disadvantages
Soil	• Allows continuous water transport • Maintains good moisture and temperature stability • Readily available and inexpensive	• Contains seeds and small plants • Prone to vegetation growth and animal activity • Difficult to remove from the mosaic surface
Sand	• Less prone to vegetation growth and animal activity • Maintains fairly stable moisture and temperature levels • Clean • Readily available and inexpensive	• Limits the continuous movement of water • Can contain salts
Gravel	• Less prone to vegetation growth and animal activity • Clean • Easy to remove • Readily available and inexpensive	• Inhibits the continuous movement of water • Poor moisture and temperature stability • Hard with sharp edges • Heavy
Other natural materials *(pozzolana, " tiff ", etc.)*	• Allows continuous water transport • Maintains fairly stable moisture and temperature levels • Inexpensive near their place of extraction • For "tiff", less prone to vegetation growth	• Dirties the mosaic surface • Hard to remove from the mosaic surface • Not available everywhere • For "tiff", can create concretions on the mosaic surface
Specialized synthetic materials *(Expanded clay – Leca™, expanded polystyrene, etc.)*	• Less prone to vegetation growth and animal activity • Clean • Very easy to remove • Lightweight	• Inhibits the continuous movement of water • Poor moisture and temperature stability • Hard to obtain and expensive

Other natural materials

Some friable and weakly agglomerated rocks and volcanic "earths", such as pozzolana, or "tiff", a calcareous "sand" found in Tunisia, are also used as fill materials. These materials are quarried and sold directly in powder form. Both materials allow good liquid-water/water-vapor transport, provide a good temperature and moisture stability and, especially in the case of "tiff", do not promote vegetation growth. Both materials are very inexpensive when purchased directly at their place of extraction, but their availability is often localized: pozzolana is found almost exclusively in Italy, while "tiff" is found in Tunisia.

On the other hand, when placed in direct contact with the tessellatum, pozzolana will dirty the mosaic surface, while "tiff" can create concretions on it.

Specialized synthetic materials (expanded clay pellets – Leca™, beads or sheets of expanded polystyrene, etc.).

These materials are generally chosen because they are lightweight, making them easy to use, and because of their insulating properties. However, they do not allow good transport of liquid-water, nor maintain stable moisture levels. They are expensive and not easily available.

Some natural materials of volcanic origin, such as grains of tuff or pumice, which have characteristics similar to synthetic materials, are sometimes used as fill material as well.

Separation membranes

The most commonly used separation membranes are plastic sheets, plastic netting, woven plastic sheets (used to make storage bags), and other synthetic fabrics, such as geotextiles. Each has its own advantages and disadvantages and its positive and negative impact on the mosaic (Table 4).

Plastic sheets

It is strongly recommended not to use plastic sheeting because it will stop any liquid-water/water-vapor transport. The water trapped under the plastic sheet will foster vegetation growth. However, plastic sheets are efficient in separating fill materials from each other and from the mosaic. They are readily available and inexpensive.

Table 4 Separation Membranes

Type	Advantages	Disadvantages
Plastic sheets	• Partially effective against vegetation penetration and animal activity • Effective separation between all fill materials • Easily available and inexpensive	• Inhibits liquid-water/water-vapor transport • Promotes root growth underneath
Plastic netting	• Permits liquid-water/water-vapor transport • Does not promote root growth underneath • Easily available and inexpensive	• Ineffective barrier to vegetation penetration and animal activity • Ineffective separation of smaller fill particles
Woven plastic sheeting	• Effective separation between all types of fill materials • Easily available and inexpensive	• Reduces liquid-water /water-vapor transport • Fairly ineffective barrier to vegetation penetration and animal activity • Promotes growth of roots underneath
Non-woven geotextiles and other synthetic fabrics	• Permits water-vapor transport • Partially effective against vegetation penetration and animal activity • Effective separation between all types of fill materials	• Reduces liquid-water transport • Promotes growth of roots underneath • Hard to obtain and very expensive

Plastic netting

Plastic netting, such as mosquito nets, allows liquid-water/water-vapor transport. It efficiently separates coarse fill materials, such as gravel, but it will let finer materials, such as soil and sand, through. It will not prevent vegetation penetration and animal activity, but is inexpensive and easily available.

Woven plastic sheets

Woven plastic sheeting, used for example to make storage bags, strongly reduces liquid-water as well as water-vapor transport, often creating a humid area just below the woven plastic sheet that promotes root growth. It only partially prevents animal activity. It efficiently separates all fill materials, is not too expensive and often locally available.

Geotextiles and other synthetic fabrics

Geotextiles are made to be used underground. They are used particularly in civil engineering projects, such as road construction, to prevent soil erosion, for example. They are generally expensive and can be difficult to obtain. There are many different types of geotextiles and each type has its own properties. They are two main categories: woven and non-woven geotextiles. The latter are recommended for reburials.

Geotextiles are effective separators of fill materials and prevent erosion of materials under them. They generally avert root penetration and animal activity. Performance related to liquid-water/water-vapor transport depends on each type of geotextile, which is why it is important to choose a geotextile carefully and ensure it is suited to the purpose it will serve in a reburial design.

Other synthetic fabrics may be used for mosaic reburial. These are often non-woven polyester fabrics, used in agriculture or construction. They are very similar to some geotextiles, but they are of inferior quality and therefore, generally have a shorter lifespans. These materials are easier to find and less expensive than geotextiles.

It is generally not recommended to lay a geotextile directly over a mosaic because it is often difficult to ensure the intimate contact between the geotextile and the entire mosaic surface. In places where this contact does not occur, liquid-water transport between the mosaic and the burial materials will not occur.

Reburying a mosaic

As for any intervention, reburial should be preceded by a thorough study of the mosaic including a condition assessment. Some stabilization work should also be carried out before reburial. It is especially important to remove any soil and all the plants and their associated roots found on and around the mosaic because the reburial environment is generally favorable to vegetation growth. It is imperative to stabilize the most damaged areas and address structural problems that could worsen during the reburial or when the fill is removed.

In the case of a mosaic re-laid on reinforced concrete panels and replaced in situ, reburial in the medium as well as in the long term is not recommended. Indeed, the oxidation of the iron of the panel reinforcements will continue once the mosaic is reburied, which will cause an increase in volume of the metal reinforcements and the continuing deterioration of the panel and the tessera layer that it supports.

In designing a reburial, it is always necessary to find a way to contain the fill materials. In areas where the walls of the room cannot be used for this purpose, wooden planks can be used, a dry stone wall (without mortar) can be built, or a wall made of soil- or sand-filled bags can be made.

It may become necessary to remove the reburial materials from the surface of a mosaic, either because the reburial was designed as a temporary protection, or simply to inspect the condition of the mosaic. When uncovering a buried mosaic, fill materials and separation layers should be carefully and gradually removed one after the other, paying particular attention to the removal of materials in direct contact with the mosaic.

A reburial design will differ depending on the type of protection required.

Reburial can be temporary, between two excavation seasons or during the winter for example. In these cases, easily removable fill materials should be used, i.e. by placing fill materials in bags and not in too great a thickness (example D, Figure 26).

Reburial can be conceived as a long-term protection within the framework of the conservation plan of an entire site, if, for example, the choice is made to show only some of the mosaics to the public. In this case, the reburial design should provide for greater thickness (examples B and C, Figure 26).

It may also be necessary to conceive a reburial as a medium-term protection or to design a reburial as a rescue measure to provide urgent protection for a mosaic in cases when a full intervention is not immediately feasible (example A, Figure 26).

Reburial planning must be part of the general management and maintenance plan for a site. Like any intervention, it requires regular maintenance, in particular, any vegetation growing on or in it should be regularly removed to avoid further deterioration of the reburied mosaic. Condition inspections of a reburied mosaic can be carried out regularly, every few years, especially if the reburial burden is fairly thin, or if certain areas of the mosaic are fragile and it is therefore important that they are regularly monitored. However, the maintenance of a reburied mosaic is generally less time-consuming than that of a mosaic left exposed in the open air. Reburial is therefore an intervention that should be carried out when human or financial resources are not sufficient to properly maintain a mosaic left in the open air or under a shelter.

CHAPTER 6

MAINTENANCE OF MOSAICS RE-LAID ON REINFORCED CONCRETE PANELS AND REPLACED IN SITU

THE DIFFERENT METHODS AND MATERIALS WHICH HAVE BEEN USED TO DETACH AND RELAY MOSAICS

In the past, the most common way to conserve mosaics was to remove them from their original location and to re-lay them on a new support, a practice that continues today. Mosaics were then displayed in a museum, placed in storage or replaced on site in their original location. This practice of detaching mosaics from their original foundation mortars is now regarded as inappropriate, not only because the detachment process damages a mosaic, but also because of the consequent loss of most of the original material of a mosaic as well as its architectural context, thereby severely compromising the authenticity of a mosaic. The detachment and lifting of a mosaic is currently considered an option only in very exceptional cases.

A detached mosaic suffers its initial damage during the lifting process. In most cases, the mosaic is subject to many mechanical stresses during this operation. It is also normally divided into sections which often leads to the loss of a large quantity of tesserae along the cutting lines. Finally, after being separated from its original mortar layers which are usually then lost irrevocably, the operation of relaying the mosaic on a new support inevitably increases the tessellatum surface area and flattens its surface, resulting in a loss of authenticity of its appearance. The new support of the re-laid tessellatum is usually divided into several panels that are reassembled in situ or in a museum. The joints between panels are then filled with tesserae or only mortar.

Sometimes, however, mosaics are lifted without being immediately re-laid on a new support. They can remain for years or decades in this condition, with only the tesserae glued to canvas,

which makes them very vulnerable and exposes them to irreversible damage due to the loss of tesserae.

The new supports most commonly used to relay a lifted mosaic are:

- ***Panels of plaster of Paris reinforced with hemp canvas mounted on a wooden frame.*** This type of support has been used in the past, especially during the first half of the 20th century, but it is still sometimes used today. The panels made with these materials are quite thick but not excessively heavy. They can only be used if the re-laid mosaic is kept in an environment protected from moisture, like in a museum or in a storage facility. Mosaics on plaster panels are usually installed vertically on a wall, or more rarely, on a floor.
- ***Panels of cement mortar reinforced by a grid of steel bars (reinforced concrete).*** This type of support has been used since the early 20th century, but it is particularly common for mosaics re-laid between the 1950s and the 1980s. These panels are usually quite thin, but they are heavier and stiffer than panels made of wood, plaster and hemp. The mosaics re-laid on reinforced concrete can be installed on walls or on floors, in a museum or in a storage facility, but they can also be replaced outdoors in an archaeological site.
- ***Composite panels, often laminated, made of modern synthetic materials.*** A common type of composite panel is composed of aluminum honeycomb sandwiched between two layers of fiberglass-reinforced resin.
  This type of support is more recent and has been used since the 1980s. These panels are thin and very light. They are mainly used for mosaics kept indoors in museums and in storage, usually installed on walls. They can also be used for displaying mosaics on floors in museums, or more rarely in archaeological sites under a shelter, if they are not subject to being walked on.

THE DETERIORATION OF MOSAICS RE-LAID ON REINFORCED CONCRETE PANELS AND REPLACED IN SITU

When carrying out maintenance and conservation work on mosaics in archaeological sites, one frequently encounters detached mosaics re-laid on reinforced concrete panels and replaced in situ which are severely damaged, in nearly all cases due to the deterioration of the support panel materials.

By far the most common deterioration mechanism of reinforced concrete panels is the oxidation of the reinforcing steel bars which, in particular, causes an increase in their volume. The presence of soluble salts in the cement, but also the penetration of water through micro-fractures, promotes corrosion of the metal re-bars. Steel corrosion products, being more voluminous than the original metal, will exert strong pressure on the concrete around them. Over time, this phenomenon causes cracking of the reinforced concrete panel which can lead to bulging of the tessellatum adjacent to the steel rebar and its detachment from the panel. This deterioration process, which takes place with any reinforced concrete, is accelerated and exacerbated by the use of poor quality materials and poor panel construction. For example, the damage will be aggravated if the panel is too thin, whether it was done to reduce its weight or its cost, or if the re-bars were incorrectly positioned, especially if they were placed too close to the tesserae layer.

Reinforced concrete panels are also sometimes subject to deformation over their entire thickness, resulting in a concave panel with uplift of its edges. While the cause of this panel bowing is not clear, it leads to the separation of panels from each other, tessellatum detachment and loss of tesserae.

The authenticity and strength of mosaics re-laid on reinforced concrete panels are already seriously compromised by this previous restoration intervention. Once deteriorated, these mosaics are particularly problematic to conserve, and there are still no real long-term solutions. Their deterioration can be slowed down by modifying their immediate surroundings. For example, a mosaic can be protected by a shelter or kept away from sources of moisture. The reburial of a mosaic on a reinforced concrete panel will provide a more stable environment, but in the long-term good results will not be obtained due to the continuing presence of moisture and consequent on-going corrosion of the steel re-bars. It is also possible to intervene in a localized manner, while keeping the mosaic panels in situ. However, the treatment of reinforced concrete panels on site without moving them to a conservation workshop is generally difficult to carry out, and such interventions cannot be considered a long-term solution for the conservation of deteriorated mosaic panels. The following section provides a basic description of in situ stabilization treatments for reinforced concrete panels.

IN SITU MAINTENANCE TREATMENTS OF MOSAICS RE-LAID ON REINFORCED CONCRETE PANELS

The in situ treatment of a deteriorated re-laid mosaic panel is an intervention that only aims to stabilize areas where the corrosion of re-bars is already well-advanced, and where the tessellatum is already detached from the panel. It does not try to resolve the general problem of the rebar corrosion by treating the entire panel or by removing the causes of this corrosion.

The procedure involves the removal of part or, if possible, the totality of the rebar that is causing the damage, working from the upper surface of the mosaic panel. It should be noted that as the corroded re-bars are removed from the panel, it will become more fragile, losing the structural unity provided by the metal reinforcements. Consequently, the concrete panel will become more and more susceptible to structural fracturing.

The treatment is generally performed by carrying out the following steps:

- Complete cleaning of the area of the mosaic panel subject to deterioration from a corroded rebar;
- Facing of the area;
- Temporary removal of the section of the tessellatum located above the corroded rebar, if tesserae are still present;
- Removal of the rebar remains, and cleaning of the area to remove debris;
- Treatment of other adjacent re-bars that are visible but left in situ;
- Filling of the void left by the removed rebar and concrete debris;
- Replacing the tessellatum section previously removed;
- Removal of the facing including all of the adhesive;
- Filling of the joints, cracks and lacunae;
- Complete documentation of the intervention.

Such an operation is quite delicate, especially if it requires the lifting of a tessellatum section to uncover the re-bars located inside the panel, when tesserae located above the corroded rebar are still present. In this case, to limit the risks of the operation, the tessellatum is faced with gauze, or light cotton fabric, over an area that contains both the section to be lifted and an area of the mosaic immediately adjacent to it that will not be lifted. In this way, the tessellatum can be held together intact during the operation, while allowing the damaged section to be opened like a book without removing it entirely.

The glue used should have the ability to adhere well to the tesserae in order to hold them together during the lifting of the tessellatum section, but it must also be easily removed at the end of the intervention. Adhesives commonly used for this operation are vinyl resin emulsions, acrylic resin solutions or animal glues, each having specific characteristics that determine its choice and use.

When resetting the tessellatum and stabilizing the intervention area after removal of the facing, it is necessary to use a mortar which contains cement in order to insure a good bond with the concrete support panel. A mortar containing only lime as a binder is not effective to fill the cracks and voids left by the steel bar removal, and to reset a tessellatum section back on a reinforced concrete panel.

The treatment of damaged reinforced concrete mosaic panels replaced in situ is very often a complex task, involving various operations that require experience from whomever carries it out. The in-situ stabilization of the most damaged areas of a reinforced concrete panel can still be considered a maintenance operation. However, the long-term conservation of such panels may require their complete dismantling and removal to a workshop, the removal of the old reinforced concrete support, and the re-laying of the tessellatum sections in situ on new lime-based mortar layers. This latter operation is considered a conservation intervention in its own right (page 86) and should not be undertaken without the guidance and supervision of a conservator.

APPENDIX A: LIST OF MATERIALS FOR DOCUMENTATION

_________Drawing board
_________Pencil and eraser
_________Pencil sharpener
_________Ball-point pens
_________0.1 or 0.2 black ink ultra fine point pen
_________Razor blade
_________Felt pens and colored pencils
_________Permanent markers for writing on plastic transparent sheets
_________White liquid paper correction fluid
_________Rulers and triangles
_________Masking tape
_________A4 and A3 plain paper
_________A4 and A3 graph paper
_________A4 and A3 tracing paper
_________A4 and A3 plastic transparent sheets
_________Colored sticker dots

_________Data Forms
_________Photocopies (blank copies) of the base drawing or photograph
_________Archive box
_________Folders
_________Binders
_________Plastic sheet protectors
_________A3 portfolio
_________Paper clips
_________Transparent Scotch tape
_________Scissors
_________Stapler and staples
_________Writing pads

_________Soft brush
_________String
_________Equipment to keep the string taut (nails, wooden planks, stones, etc.)
_________Large wooden framing squares
_________2-meter folding ruler
_________5-meter retractable measuring tape
_________20-meter reel measuring tape

_________Digital camera
_________Memory card
_________*Photograph Log*
_________Stepladder or short ladder
_________Small chalkboard
_________White chalk
_________Black and white metric scale
_________Arrow to indicate North
_________Compass
_________Computer
_________Printer

APPENDIX B: LIST OF MATERIALS FOR AN INTERVENTION CAMPAIGN

______Tool box
______Scalpels with interchangeable blades
______Scalpel blades
______Scalpels with fixed blade
______Spatulas
______Dental spatulas
______Dental picks
______Tweezers
______Chisels (width 3–10 mm)
______Hammers (weight 200–500 g)
______Hand drills and bits (2–2.2 mm)
______Syringes (volume 20-50 cc)
______Needles for syringes (diameter 1.8–2.2 mm)
______Petroleum jelly
______Trowels

______Small dustpans and brushes
______Flat paint brushes (width 2–6 cm)
______Toothbrushes
______Nailbrushes
______Large brushes
______Sponges
______Cotton
______Colored sticker dots
______Wooden sticks
______Rubber manual blower bulbs
______Small rubber bowls to mix mortar
______Hand-held water sprayers
______Water buckets

______Rubber gloves
______Disposable gloves
______Small knee pads
______Sun umbrellas
______Paper dust masks
______Goggles

______Pliers
______Pincers
______Screwdrivers
______Wood and metal saws
______Nails
______Sharpening stone and mineral oil

______Vacuum cleaner
______Storage bins for aggregates and binders
______Plastic pitchers
______Plastic containers for tesserae
______Mortar buckets
______Sieves (opening sizes 0.25 mm, 0.5 mm, and 1 to 5 mm)
______Wheelbarrow
______Mortar mixer
______Shovels
______Brooms
______Floor cloths
______Plastic sheets
______String

______Storage tent for materials
______Water hose
______Water cistern
______Electrical extension cord
______Generator

______Lime putty
______Natural hydraulic lime
______Sands
______Gravels
______Crushed brick
______Fine ceramic and stone powders for grouting

______Woven plastic sheeting
______Plastic netting (mosquito net)
______Geotextile

______Gauze or light-weight cotton cloth
______Adhesive for facing
______Small drill with discs for cutting
______Anti-rust paint and solvent
______Small brush
______White cement
______Small burner (electric or gas)

The Getty Conservation Institute

Institut National du Patrimoine

MOSAIKON

$0.00
ISBN 978-0-9834922-5-2
90000>
9 780983 492252